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 NATIONAL BUREAU OF STANDARDS-1963-A

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DELAWARE RIVER BASIN,  
QUEEN ANNE CREEK,  
PENNSYLVANIA,

NDI ID PA-00945  
PA DER 9-156

LEVEL II

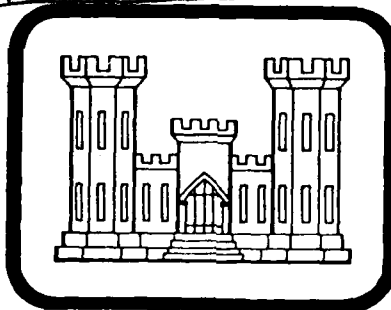
LAKE CAROLINE DAM

OWNED BY

BUCKS COUNTY DEPT. OF PARKS AND RECREATION

PHASE I INSPECTION REPORT,  
NATIONAL DAM INSPECTION PROGRAM.

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BY

O'BRIEN & GERE

PHILADELPHIA, PENNSYLVANIA  
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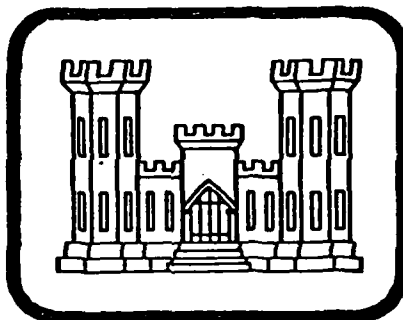
DELAWARE RIVER BASIN

LAKE CAROLINE DAM  
PENNSYLVANIA

NDI ID PA 00945

OWNED BY  
BUCKS CO. DEPT. OF PARKS & RECREATION

PHASE I INSPECTION REPORT  
NATIONAL DAM INSPECTION PROGRAM



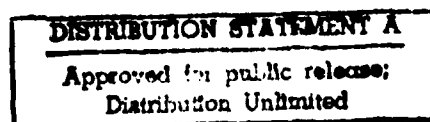
Prepared for:

DEPARTMENT OF THE ARMY  
Baltimore District, Corps of Engineers  
Baltimore, Maryland 21203

Prepared by:

O'BRIEN & GERE ENGINEERS, INC.  
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Philadelphia, Pennsylvania 19103

FEBRUARY 1981



## PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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By	<i>Sean [signature]</i>
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## PHASE I REPORT

### NATIONAL DAM INSPECTION PROGRAM

Name of Dam:	Lake Caroline Dam
State Located:	Pennsylvania
County Located:	Bucks
Stream:	Queen Anne Creek
Coordinates:	Latitude 40°10.5', Longitude 74°51.3'
Date of Inspection:	December 16, 1980

### ASSESSMENT

Lake Caroline Dam is an earth embankment with a central core of selected earth fill and consists of a 45-foot wide concrete Ogee spillway. The embankment is approximately 1,180 feet long with a maximum height of about 11 feet and an average top width of approximately 15 feet. The impounded reservoir has a normal pool storage capacity of 32 acre-feet and a maximum storage capacity of 104 acre-feet. The dam was constructed on Queen Anne Creek for recreational purposes.

The selected Spillway Design Flood (SDF) for this "Small" size, "Significant" hazard dam is one-half of the Probable Maximum Flood (PMF). The spillway is capable of discharging approximately 12 percent of the PMF prior to overtopping the low point of the top of the dam. The spillway is classified as "Inadequate", but not "Seriously Inadequate", because the dam is considered to be a "Significant" hazard structure.

Based on the visual observations and review of the information provided by the Pennsylvania Department of Environmental Resources (DER), Division of Dam Safety, Lake Caroline Dam is considered to be in fair condition.

#### Recommendations and Remedial Measures:

The following recommendations and remedial measures should be initiated immediately. The Owner should retain the services of a licensed Professional Engineer experienced in the design and construction of dams to assist in complying with the recommendations and remedial measures.

##### a. Facilities.

1. The dam should be raised to design elevation, regraded and provided with erosion resistant vegetative cover.
2. Detailed hydrologic and hydraulic analyses should be performed to evaluate the discharge capacity of the spillway and remedial measures should be taken to increase the spillway capacity.
3. Riprap should be replaced on the upstream face of the dam to protect against wave action.

## LAKE CAROLINE DAM

4. Bushes and small trees growing on the embankment should be removed. Any remaining voids should be backfilled with suitable, thoroughly compacted material.


5. Debris should be removed from the spillway outlet channel.

b. Operation and Maintenance Procedures.

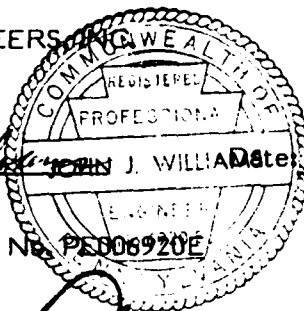
1. A regular inspection and maintenance program should be developed and implemented. This program should include periodic operation of the outlet works gate.

2. A system of warning downstream residents during periods of extreme rainfall should be developed.

O'BRIEN & GERE ENGINEERS

  
John J. Williams, P.E.  
Vice President

Pennsylvania Registration No. PE006920E



Date: 18 FEB. 1981

Approved by: 

JAMES W. PECK  
Colonel, Corps of Engineers  
District Engineer

Date: 4 March 1981





UPSTREAM OVERVIEW OF LAKE CAROLINE DAM FROM THE EAST  
ABUTMENT. (12/16/80)



DOWNSTREAM OVERVIEW OF LAKE CAROLINE DAM FROM THE WEST  
ABUTMENT. (12/16/80)

## TABLE OF CONTENTS

	<u>PAGE</u>
Preface	i
Assessment	ii
Overview Photograph	iv
 SECTION 1 - PROJECT INFORMATION	
1.1 General	1
1.2 Description of Project	1
1.3 Pertinent Data	2
 SECTION 2 - ENGINEERING DATA	
2.1 Design	5
2.2 Construction	5
2.3 Operational Data	5
2.4 Evaluation	5
 SECTION 3 - VISUAL INSPECTION	
3.1 Findings	6
3.2 Evaluation	6
 SECTION 4 - OPERATIONAL PROCEDURES	
4.1 Procedures	8
4.2 Maintenance of the Dam	8
4.3 Maintenance of Operating Facilities	8
4.4 Description of any Warning Systems in Effect	8
4.5 Evaluation	8
 SECTION 5 - HYDROLOGY AND HYDRAULICS	
5.1 Evaluation of Features	9
 SECTION 6 - STRUCTURAL STABILITY	
6.1 Evaluation of Structural Stability	11
 SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND PROPOSED REMEDIAL MEASURES	
7.1 Dam Assessment	12
7.2 Recommendations and Remedial Measures	12
 APPENDIX	
A Visual Inspection	
B Checklist, Engineering Data	
C Photographs	
D Hydrologic and Hydraulic Engineering Data	
E Regional Vicinity Map and Drawings	
F Geology	

PHASE I REPORT  
NATIONAL DAM INSPECTION PROGRAM  
LAKE CAROLINE DAM  
NDI ID PA 00945  
PA DER 9-156

SECTION 1

PROJECT INFORMATION

1.1 General

a. Authority. The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose. The purpose of this inspection is to determine if Lake Caroline Dam constitutes a hazard to human life or property.

1.2 Description of Project (Based upon information obtained from the Pennsylvania Department of Environmental Resources (DER), Division of Dam Safety, Harrisburg, Pennsylvania and this inspection.)

a. Dam and Appurtenances. Lake Caroline Dam is an earth embankment approximately 1,180 feet long with a maximum height of 11 feet. The dam impounds a reservoir with a surface area of 13.5 acres and a storage capacity of 32 acre-feet at normal pool. The crest of the dam averages 15 feet wide. The side slopes (both upstream and downstream) average about 2H:1V and the upstream slope was to have been lined with riprap. A central core of selected earth fill extends 3 feet below the original ground surface (see embankment section on Sheet 3 in Appendix E). The core zone is 4 feet wide at the top of the embankment and 10 feet wide at its base.

The spillway is a 45-foot long concrete Ogee section with 4 feet of freeboard between the spillway crest and the top of the dam. The spillway is provided with concrete side walls which extend 21 feet, 6 inches downstream of the Ogee section and concrete cutoff walls which extend 7 feet beyond the outer face of the side walls and 5 feet below the channel invert. Wingwalls on both sides of the spillway extend 10 feet upstream from the Ogee section. The outlet channel invert is surfaced with grouted riprap for a distance of 8 feet, 6 inches downstream of the spillway section. A 3-foot deep by 2-foot wide keywall extends across the outlet channel at the downstream end of the grouted riprap. The channel widens into a stilling pool beyond the side walls and passes through a 6-foot high by 22-foot wide culvert for a highway embankment approximately 150 feet downstream of the spillway.

The outlet works consist of a 3-foot diameter corrugated metal pipe through the spillway section with a 4-foot high by 3.5-foot wide wood gate across the pipe opening on the upstream face of the spillway. The invert of the pipe at the outlet end is at the same elevation as the outlet channel invert.

For further details relative to the spillway system refer to sheet 3, Appendix E.

b. Location. Lake Caroline Dam is located on Queen Anne Creek in the community of Fairless Hills within Falls Township, Bucks County, PA. The dam site is shown on the USGS Quadrangle entitled "Trenton West, N.J.-Pa." at coordinates N40°10.5', W74°51.3'. A regional location plan of Lake Caroline Dam is included as Figure 1, Appendix E.

c. Size Classification. Based on the maximum storage capacity of 166 acre-feet (less than 1,000 acre-feet) and maximum height of 11 feet (less than 40 feet), Lake Caroline Dam is classified in the "Small" size category.

d. Hazard Classification. St. Frances Cabrini Elementary School is located approximately 500 feet downstream of the dam and about 220 feet left of the stream at that point. A failure of the dam could cause appreciable property damage but it is unlikely that any lives would be lost because of the regulating effect of the highway embankment about 150 feet downstream of the dam. Therefore, Lake Caroline Dam is classified in the "Significant" hazard potential category.

e. Ownership. The original owner of Lake Caroline Dam was the Danherst Corporation, Fairless Hills, Pa. The dam is presently owned by Bucks County, under the jurisdiction of the Department of Parks and Recreation. Correspondence should be sent to Mr. Charles Pfanstiel, Chief Landscape Architect, County of Bucks, Department of Parks and Recreation, Core Creek Park, Box 358, RD 1, Langhorne, PA. 19047 (Telephone: (215) 757-0571).

f. Purpose of Dam. The dam was constructed to impound a reservoir for recreational purposes. The impoundment continues to be used for recreation.

g. Design and Construction History. According to the design drawings, Lake Caroline Dam was designed in 1951 by Howard A. LeVan, Jr., registered professional engineers, Harrisburg, Pa. and Charles Haydock, Consulting Engineer, Philadelphia, PA. Construction of the dam began in 1951 and was completed in 1953. The construction was under the jurisdiction of the Danherst Corporation, Fairless Hills, PA.

h. Normal Operating Procedures. The reservoir surface is normally maintained at Elevation 66.0 (spillway crest elevation). Drawdown of the reservoir may be accomplished by sliding the wooden gate upward and allowing discharge to flow through the 36-inch diameter outlet pipe.

### 1.3 Pertinent Data

a. Drainage Area.

Square Miles	2.2
--------------	-----

b. Discharge at Dam Site (cfs).

Spillway (water surface at top of dam low point, Elev. 68.8)	760
Spillway (water surface at design top of dam, Elev. 70.0)	1,570
Outlet Works (water surface at normal pool, Elev. 66.0)	60

c. Elevation (MSL).

Spillway Crest	66.0
Discharge Notch Crest	65.5
Top of Dam (design)	70.0
Top of Dam (low point)	68.8
Outlet Works Invert Inlet	60.0
Outlet Works Invert Outlet	59.0
Streambed Elevation at Downstream Toe	59.0

d. Reservoir (feet).

Length of Normal Pool	1,600
Length of Maximum Non-Overtopping Pool	2,100

e. Storage (Acre-Feet).

Normal Pool, Elev. 66.0	32
Top of Dam (Low Point), Elev. 68.8	104
Top of Dam (Design), Elev. 70.0	166

f. Reservoir Surface Area (Acres).

Normal Pool, Elev. 66.0	14
Top of Dam (Low Point), Elev. 68.8	40
Top of Dam (Design), Elev. 70.0	64

g. Dam Data.

Type	Zoned Earth Embankment
Length	1,180 Feet
Height to Low Point Top of Dam	9.8 Feet
Crest Width	15 Feet
Side Slopes	2H:1V
Zoning	Central Core Zone
Impervious Core	Central Core of Selected Earth Fill
Cutoff	Core Zone Extends 3 feet below ground surface
Grout Curtain	None

h. Spillway.

Type	Concrete Ogee Overflow
Length of Weir	45 Feet
Crest Elevation	66.0 (Discharge Notch Elev. 65.5)
Gates	A wooden gate regulates outlet works
Upstream Channel	None

#### Downstream Channel

Concrete sidewalls extend 21.5 feet downstream of the Ogee; grouted riprap channel invert for 10 feet downstream of the Ogee. The channel passes through a highway culvert about 150 feet downstream of the dam axis. Refer to Sheet 3, Appendix E.

## SECTION 2

### ENGINEERING DATA

#### 2.1 Design

a. Data Available. The information available in the DER main office files in Harrisburg, Pennsylvania, for review of Lake Caroline Dam includes the following:

1. "Application", "Report Upon the Application", and "Permit" to construct Lake Caroline Dam.
2. General and Plan drawings for Lake Caroline Dam.
3. Sections and Details drawing for Lake Caroline Dam.
4. Inspection Report dated June 23, 1965.
5. Miscellaneous correspondence, memoranda, etc.

b. Design Features. The design features are described in Section 1.2.a and shown on the Sheets in Appendix E.

#### 2.2 Construction

Based on the field investigation and the information available from DER, the dam appears to have been constructed in general conformance with the design drawings. However, several minor discrepancies were noted during the field inspection.

#### 2.3 Operation

Operational procedures are limited to raising the wooden gate which controls discharge through the outlet works. A metal handle is provided for lifting the gate.

#### 2.4 Evaluation

a. Availability. The engineering data utilized in this report were provided by DER.

b. Adequacy. The information provided by DER, visual observations, and discussions with Mr. Charles Pfanstiel, the Owner's representative, are considered adequate for a Phase I investigation.

c. Validity. There appears to be no reason to question the validity of the data obtained from DER.

## SECTION 3

### VISUAL INSPECTION

#### 3.1 Findings

a. General. The field inspection of Lake Caroline Dam took place on December 16, 1980. At the time of the inspection, the reservoir surface was slightly below the spillway crest (Elev. 66.8) and water was flowing over the discharge notch. No underwater areas were inspected.

The observations and comments of the field inspection team appear in the checklist which is Appendix A of this report. The appearance of the facility indicates that the dam and its appurtenances are marginally maintained.

b. Dam. The crest of the embankment is below design elevation for most of the length of the dam. The low point in the crest is approximately 1.2 feet below the design elevation. The embankment crest on either side of the spillway is nearly a foot below the spillway sidewalls and the lack of vegetation indicates that in addition to pedestrian traffic some erosion has occurred adjacent to the spillway sidewalls.

The upstream face of the embankment is irregular and appears to be steeper than 2H:1V in many locations. No riprap is apparent above the water surface and bushes and small trees (up to 4-inch diameter trunks) are growing on the upstream face in several locations.

c. Appurtenant Structures. The spillway and wingwalls appeared to be in good condition at the time of the inspection. The gate for the outlet works was submerged and could not be observed.

d. Reservoir Area. The area surrounding the reservoir is extremely flat and for the most part grass covered. Some flooding of buildings and properties upstream of the dam could occur when the water surface in the reservoir reaches 2 feet above the top of the dam.

e. Downstream Channel. The downstream channel passes through a 22-foot wide by 6-foot high culvert for a highway embankment approximately 150 feet downstream of the dam. Several shopping carts were observed in the channel between the spillway and the culvert on the date of the inspection. The tailwater elevation was approximately 5 feet below the spillway crest. The channel gradient is very gentle downstream of the culvert with meandering wooded banks. About 700 feet downstream of the dam the creek flows into a shallow pond approximately 1,500 feet long.

#### 3.2 Evaluation

The low top of dam elevation results in decreased spillway discharge capacity prior to embankment overtopping and reduced capability for withstanding large flood flows. Lack of riprap on the upstream face could lead to further erosion of the already steepened slope and potential instability of the embankment. Bushes



and small trees (up to 4-inch diameter trunks) growing on the upstream face create potential seepage paths through the embankment and endanger the integrity of the structure. The general condition of the embankment is considered to be poor, and the overall condition of the dam is considered to be fair.

## SECTION 4

### OPERATIONAL PROCEDURES

#### 4.1 Procedures

The wooden gate on the upstream face of the Ogee spillway provides upstream control of the 36-inch diameter corrugated metal outlet pipe for reservoir draw-down. There are no other known operational features for the dam.

#### 4.2 Maintenance of the Dam

According to the Owner's representative, maintenance is performed on an as-needed basis.

#### 4.3 Maintenance of Operating Facilities

According to the Owner's representative, the gate is not operated on a regular basis. The gate was submerged during the inspection, and it is not known whether the outlet works are in operating condition.

#### 4.4 Description of any Warning Systems in Effect

According to the Owner's representative, no formal system of warning downstream residents of an impending dam failure is in effect for Lake Caroline Dam.

#### 4.5 Evaluation

The bushes and small trees growing on the upstream face of the dam and the eroded areas on the embankment indicate a general lack of maintenance at the site. A regular inspection and maintenance program should be established which would include periodic operation of the outlet works gate.

A system of warning downstream residents during periods of extreme rainfall should be developed and implemented.

## SECTION 5

### HYDROLOGY AND HYDRAULICS

#### 5.1 Evaluation of Features

a. Design Data. Lake Caroline Dam has a drainage area of 2.2 square miles and impounds a reservoir with a normal pool storage capacity of 32 acre-feet. The ground surface ranges from Elev. 205 in the upper reaches of the watershed to Elev. 66 at normal pool. The terrain of the drainage basin adjacent to the reservoir is flat with slopes ranging from approximately 0.5 to about 3 percent. An estimated 90 percent of the watershed is developed for residential and commercial purposes with the balance primarily wooded.

No original design calculations were available, however, the "Report Upon the Application" indicated that a spillway capacity of 1370 cfs (using a coefficient of 3.8) was estimated.

b. Experience Data. According to the Owner's representative, there are no known reservoir level records or rainfall records kept for this dam. However, an inspection report dated June 23, 1965 indicated that the spillway abutments had been eroded by overtopping at some previous date. Subsequent correspondence from the original owner (Danherst Corporation, Fairless Hills, PA) stated that the embankment had been repaired.

c. Visual Observations. During the field inspection, it was noted that the spillway abutments had been eroded again, apparently due to overtopping. It was also noted that the downstream highway culvert could constrict the outflow from Lake Caroline Dam, causing submergence of the spillway. According to the hydraulic calculations (refer to Appendix D) beginning with pool Elev. 69.7 the highway culvert would control the discharge from the dam with the low point of the top of the dam at El. 68.8.

d. Overtopping Potential. According to the Guidelines, the recommended Spillway Design Flood (SDF) for a "Small" size, "Significant" hazard dam ranges from the 100-year flood to one-half of the Probable Maximum Flood (PMF). Due to the close proximity of the elementary school to the dam and the downstream channel, the selected SDF is one-half of the PMF.

Various percentages of the PMF were routed through Lake Caroline Dam by means of the HEC-1 DB computer program. A brief description of the program is included in Appendix D. The peak inflow and outflow rates for the SDF were computed to be 5,500 cfs and 4,100 cfs, respectively. Based on the hydrologic and hydraulic analyses, the spillway is capable of discharging approximately 12 percent of the PMF prior to overtopping of the low point of the top of the embankment (Refer to Appendix D, Sheet 12). The SDF would overtop the dam by a maximum of 3.2 feet and the duration of overtopping would be about 6.3 hours. If the dam were raised to design Elev. 70.0, the spillway would be capable of discharging approximately 20 percent of the PMF before overtopping of the embankment would occur (Refer to Appendix D, Sheet 16).

e. Spillway Adequacy. The Lake Caroline Dam spillway is classified as "Inadequate", but not "Seriously Inadequate" because even though the spillway is capable of discharging only 12 percent of the PMF, the dam is considered to be a "Significant" hazard structure.

A highway embankment approximately 150 feet downstream of the dam would control discharge from Lake Caroling Dam. Therefore, outflow due to breaching of the dam would be regulated by the highway embankment and the downstream effect would be minimized. However, a failure of the downstream highway embankment could create a hazard to loss of life downstream. The highway embankment would experience a maximum overtopping depth of approximately 2.5 feet and an overtopping duration of about 6 hours for the SDF. It is considered unlikely that the embankment would fail under these conditions since it is surfaced with a 4-lane highway, has a top width of approximately 70 feet and is only about 11 feet high.

## SECTION 6

### STRUCTURAL STABILITY

#### 6.1 Evaluation of Structural Stability

a. Visual Observations. The upstream face of the dam appears to be steeper than originally designed indicating that wave action has apparently eroded the upstream face and consequently has probably decreased the stability of the slope. Further erosion will probably occur since no riprap was evident during the inspection.

The top of the dam is as much as 1.2 feet below the design top of dam elevation. An inspection report of June 1965 indicated that the spillway abutments had been overtopped at some previous date. Conceivably the dam may have been overtopped and eroded since 1965.

The roots of bushes and small trees (up to 4-inch diameter trunks) growing on the upstream face of the embankment create seepage paths through the embankment and could potentially weaken the structure.

The structural features of the spillway appeared to be in good condition at the time of the inspection.

Based on visual observations, the dam appears to be structurally stable.

b. Design and Construction Data. Design drawings, application data, and inspection reports and photographs were provided by DER. However, no design calculations were included in the provided information.

c. Operating Records. According to the Owner's representative, no official operating records are maintained for this dam.

d. Post Construction Changes. No records are available for any structural changes to the dam subsequent to the completion of construction. The correspondence indicates that the spillway abutments were repaired in 1965 following an overtopping of the embankment.

e. Seismic Stability. Lake Caroline Dam is located in Seismic Zone 1 on the Seismic Zone Map of Contiguous States. A dam located in Seismic Zone 1 is generally considered to be safe under any expected Zone 1 earthquake loading conditions if it is stable under static loading conditions.

## SECTION 7

### ASSESSMENT, RECOMMENDATIONS AND PROPOSED REMEDIAL MEASURES

#### 7.1 Dam Assessment

a. Safety. The visual inspection and review of available information indicate that Lake Caroline Dam is in fair condition.

The top of the dam is as much as 1.2 feet below the design top of dam elevation which causes the discharge capacity prior to overtopping of the embankment to be reduced.

The upstream face of the dam is not protected by riprap and has been eroded to a steeper slope by reservoir wave action. In addition, bushes and small trees are growing on the upstream face of the embankment.

The spillway is capable of discharging approximately 12 percent of the PMF prior to overtopping of the low point of the top of the dam (the SDF is 50 percent of the PMF). The SDF would overtop the dam by a maximum of 3.2 feet and the duration of overtopping would be about 6.3 hours. The spillway is classified as "Inadequate", but not "Seriously Inadequate" because the dam is considered to be a "Significant" hazard structure.

b. Adequacy of Information. The information available from DER, visual observations, and discussions with the Owner's representative are considered adequate for a Phase I investigation.

c. Urgency. The remedial measures recommended in Section 7.2 should be effected immediately.

d. Necessity for Further Investigation. Detailed hydrologic and hydraulic analyses should be performed to determine the extent to which the spillway capacity and the downstream culvert capacity should be increased.

#### 7.2 Recommendations and Remedial Measures

The following recommendations and remedial measures should be initiated immediately. The Owner should retain the services of a licensed Professional Engineer experienced in the design and construction of dams to assist in complying with the recommendations and remedial measures.

##### a. Facilities

1. The dam should be raised to design elevation, regraded and provided with erosion resistant vegetative cover.

2. Detailed hydrologic and hydraulic analyses should be performed to evaluate the discharge capacity of the spillway and remedial measures should be taken to increase the spillway capacity.

3. Riprap should be placed on the upstream face of the dam to protect against wave action.

4. Bushes and small trees growing on the embankment should be removed. Any remaining voids should be backfilled with suitable, thoroughly compacted material.

5. Debris should be removed from the spillway outlet channel.

b. Operation and Maintenance Procedures

1. A regular inspection and maintenance program should be developed and implemented. This program should include periodic operation of the outlet works gate.

2. A system of warning downstream residents during periods of extreme rainfall should be developed.

APPENDIX A  
CHECKLIST  
VISUAL INSPECTION

O'BRIEN & GERE



CHECK LIST  
VISUAL INSPECTION  
PHASE I

Sheet 1 of 11

Name Dam Lake Caroline Dam County Bucks State Penna. National ID PA 00945

Type of Dam Earth Embankment Hazard Category High

Date(s) Inspection Dec. 16, 1980 Weather Rain Temperature 35<sup>0</sup> F.

Pool Elevation at Time of Inspection 66.0 M.S.L. Tailwater at Time of Inspection 61.0 ± M.S.L.

Inspection Personnel:

Lee DeHeer Leonard Beck Robert Bowers

Jon Rauschkolb \_\_\_\_\_

Lee DeHeer Recorder

Remarks:

Mr. Charles Pfanstiel, Chief Landscape Architect for the Bucks County Department of Parks and

Recreation, was present during the inspection.

\_\_\_\_\_

# CONCRETE/MASONRY DAMS

Sheet 2 of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	N/A	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	N/A	
DRAINS	N/A	
WATER PASSAGES	N/A	
FOUNDATION	N/A	

CONCRETE/MASONRY DAMS

Sheet 3 of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	N/A	
STRUCTURAL CRACKING	N/A	
VERTICAL AND HORIZONTAL ALIGNMENT	N/A	
MONOLITH JOINTS	N/A	
CONSTRUCTION JOINTS	N/A	

EMBANKMENT

Sheet 4 of 11

<u>VISUAL EXAMINATION OF</u>	<u>OBSERVATIONS</u>	<u>REMARKS OR RECOMMENDATIONS</u>
<u>SURFACE CRACKS</u>	None observed.	
<u>UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE</u>	None observed.	
<u>SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES</u>	The upstream slope is steeper than 1H:1V in some locations, apparently due to wave action erosion.	The upstream face of the dam should be regraded to a 2H:1V slope with riprap to protect against wave action.
<u>VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST</u>	The top of the dam is as much as 1.2 feet below design elevation. Refer to sheet 11B of 11.	The top of the dam should be raised to design elevation.
<u>RIPRAP FAILURES</u>	No riprap was evident above the water surface.	Riprap should be placed along the upstream face to protect against wave action.

EMBANKMENT

Sheet 5 of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
-----------------------	--------------	----------------------------

JUNCTION OF EMBANKMENT  
AND ABUTMENT, SPILLWAY  
AND DAM

The spillway abutments appear  
to have been eroded by over-  
topping.

The earth spillway abutments  
should be raised to design  
elevation, reseeded on the  
crest and downstream face and  
riprapped on the upstream face.

ANY NOTICEABLE SEEPAGE

None observed.

STAFF GAGE AND RECORDER

None.

DRAINS

None.

OUTLET WORKS

Sheet 6 of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	None observed.	
INTAKE STRUCTURE	None.	
OUTLET STRUCTURE	The outlet structure is aligned through the spillway section.	
OUTLET CHANNEL	The outlet channel passes through a highway culvert about 100 feet downstream of the dam. Several shopping carts were lying in the channel at the time of the inspection.	The shopping carts should be removed from the outlet channel.
EMERGENCY GATE	The wood gate was submerged and inaccessible at the time of the inspection.	

UPDATED SPILLWAY

Sheet 7 of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	No problems noted.	
APPROACH CHANNEL	None.	
DISCHARGE CHANNEL	Same as the outlet channel discussed on sheet 6 of 11.	
BRIDGE AND PIERS	None.	

GATED SPILLWAY

Sheet 8 of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	N/A	
APPROACH CHANNEL	N/A	
DISCHARGE CHANNEL	N/A	
BRIDGE AND PIERS	N/A	
GATES AND OPERATION EQUIPMENT	N/A	



INSTRUMENTATION

Sheet 9 of 11

REMARKS OR RECOMMENDATIONS

OBSERVATIONS

VISUAL EXAMINATION

MONUMENTATION/SURVEYS

None.

OBSERVATION WELLS

None.

WEIRS

None.

PIEZOMETERS

None.

OTHER

None.

RESERVOIR

Sheet 10 of 11

REMARKS OR RECOMMENDATIONS

OBSERVATIONS

VISUAL EXAMINATION OF

SLOPES

Reservoir slopes are very flat and grass covered. Flooding of the park area, around the perimeter of the reservoir, could occur during significant increases in the reservoir stages.

SEDIMENTATION

No evidence of excessive sedimentation deposits were observed during the inspection.

DOWNSTREAM CHANNEL

Sheet 11 of 11

REMARKS OR RECOMMENDATIONS

VISUAL EXAMINATION OF

OBSERVATIONS

CONDITION

(OBSTRUCTIONS,  
DEBRIS, ETC.)

The channel downstream of  
the highway embankment appears  
to be relatively free of ob-  
structions.

SLOPES

The channel slope is very mild.

APPROXIMATE NO.  
OF HOMES AND  
POPULATION

An elementary school is located  
approximately 500 feet downstream  
of the dam. The floor of the school  
is about 5.5 feet above the stream bed.

TOP OF DAM BELOW DESIGN  
ELEVATION ALONG MOST OF DAM LENGTH

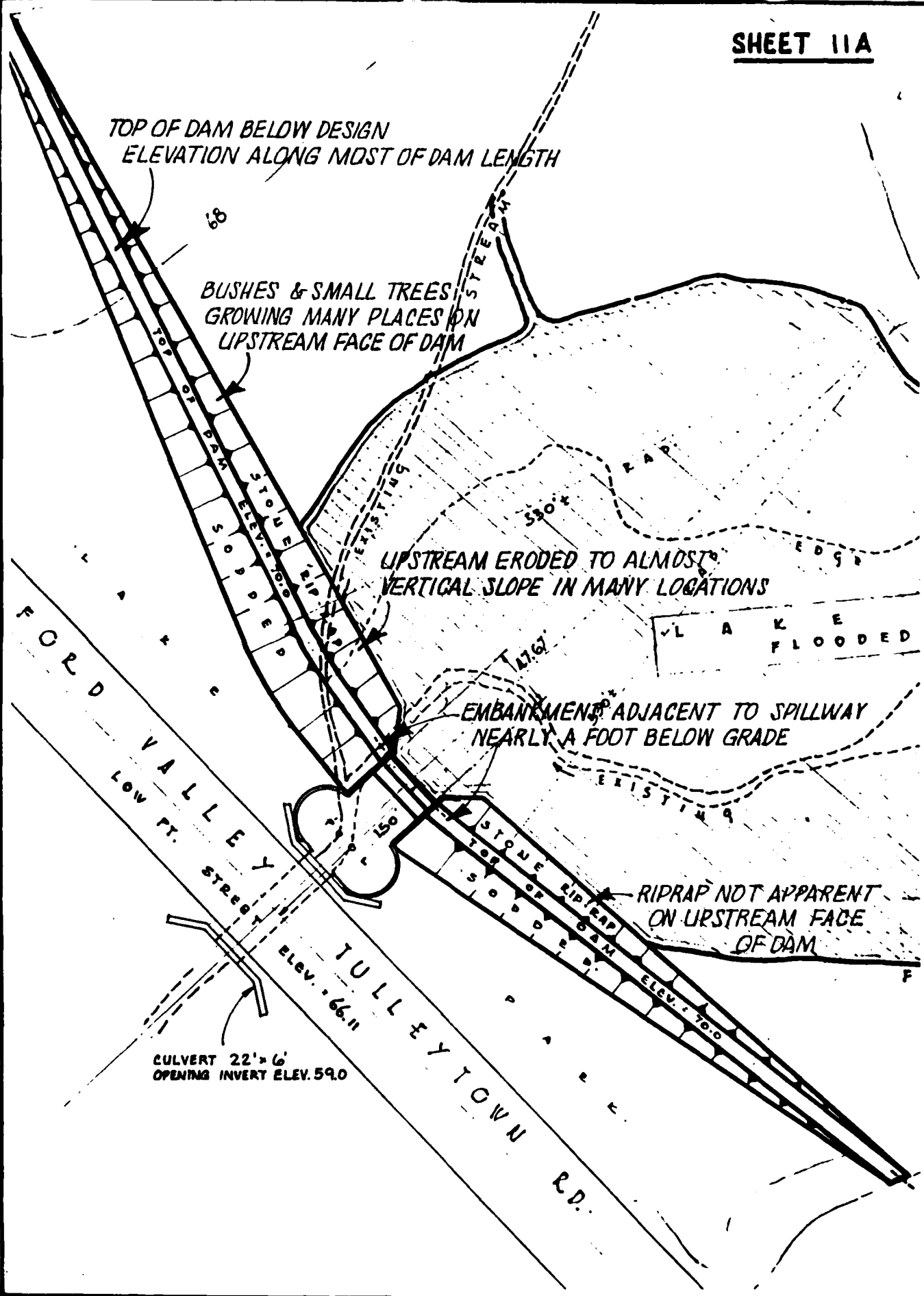
BUSHES & SMALL TREES  
GROWING MANY PLACES ON  
UPSTREAM FACE OF DAM

UPSTREAM ERODED TO ALMOST  
VERTICAL SLOPE IN MANY LOCATIONS

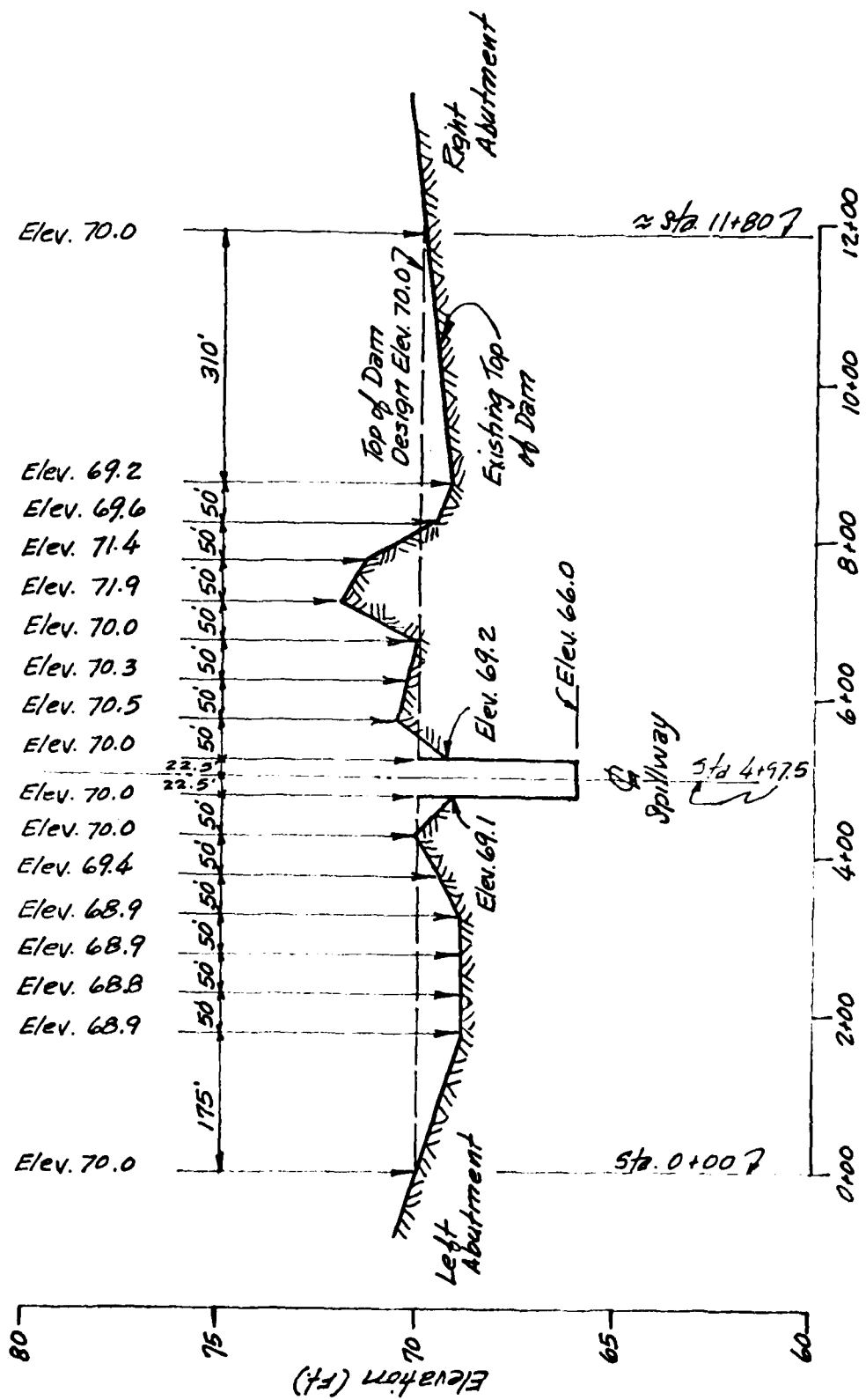
EMBANKMENT ADJACENT TO SPILLWAY  
NEARLY A FOOT BELOW GRADE

RIPRAP NOT APPARENT  
ON UPSTREAM FACE  
OF DAM

CULVERT 22' x 6'  
OPENING INVERT ELEV. 59.0



PROJECT Lake Caroline Dam, Field Observation Profile	SHEET 11B	BY R. R. B.	DATE 12/23/80	JOB NO. 1841-014
---	--------------	----------------	------------------	---------------------



APPENDIX B  
CHECKLIST  
ENGINEERING DATA

CHECK LIST ENGINEERING DATA DESIGN, CONSTRUCTION, OPERATION PHASE I	NAME OF DAM	Lake Caroline Dam
	NDI ID	PA - 00945

Sheet 1 of 4

ITEM	REMARKS
AS-BUILT DRAWINGS	None available.

REGIONAL VICINITY MAP

Refer to Figure 1 Appendix E

CONSTRUCTION HISTORY

No construction reports are available.

TYPICAL SECTIONS OF DAM

Refer to Sheet 3, Appendix E.

OUTLETS - PLAIN	}	Refer to Sheet 3, Appendix E.
DETAILS		
CONSTRAINTS		
DISCHARGE RATINGS		None available.
RATHFALL/RESERVOIR RECORDS		None available.

Sheet 2 of 4

ITEM	REMARKS
DESIGN REPORTS	None available
GEOLOGY REPORTS	None available.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None available.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY } FIELD }	None available.
POST-CONSTRUCTION SURVEYS OF DAM	None available.
BORROW SOURCES	Unknown



Sheet 3 of 4

ITEM	REMARKS
MONITORING SYSTEMS	None.
MODIFICATIONS	The spillway abutments were reported to have been repaired in 1965 following an overtopping.
HIGH POOL RECORDS	None available.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None available.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None available.
MAINTENANCE OPERATION RECORDS	None available.

Sheet 4 of 4

ITEM	REMARKS
SPILLWAY PLAN	Refer to Sheets 2&3, Appendix E.
SECTIONS	
DETAILS	
OPERATING EQUIPMENT PLANS & DETAILS	Refer to Sheet 3, Appendix E.
MISCELLANEOUS	Refer to Section 2.1.a

APPENDIX C  
PHOTOGRAPHS

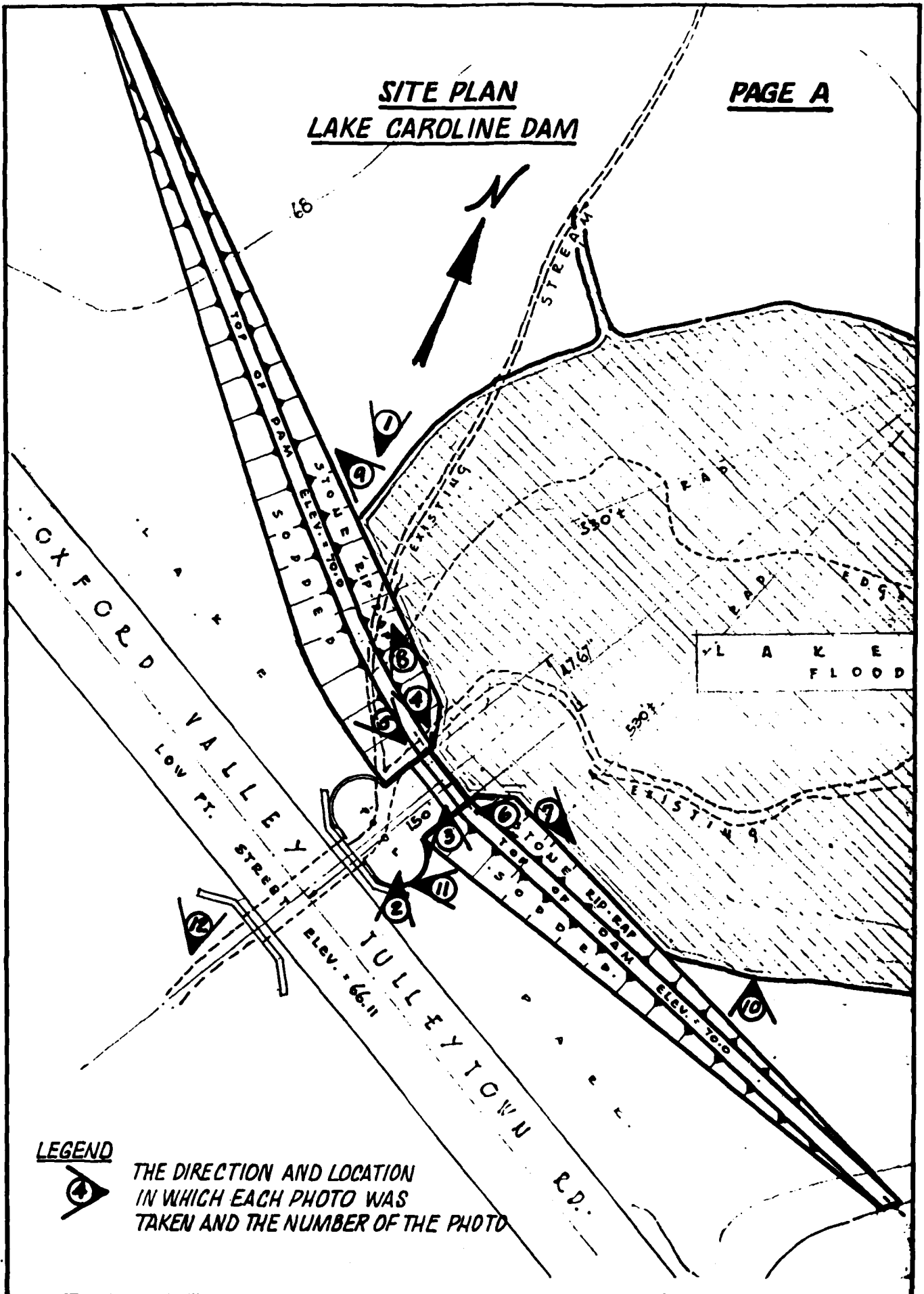
## APPENDIX C

### PHOTOGRAPHS TABLE OF CONTENTS

	<u>Page No.</u>
Site Plan	A
 <u>PHOTOGRAPH</u>	
<u>No.</u>	
1. Upstream face of dam from the west abutment showing brush and trees and lack of riprap. (12/16/80)	1
2. Looking upstream at the spillway. (12/16/80)	1
3. Spillway from east sidewall. (12/16/80)	2
4. Embankment below grade just west of spillway sidewall. (12/16/80)	2
5. Embankment about one foot below grade along west spillway sidewall. (12/16/80)	3
6. Embankment about one foot below grade along east spillway sidewall. (12/16/80)	3
7. Over all condition of upstream face of dam embankment. (12/16/80)	4
8. Typical vegetation growth on upstream face of dam embankment. (12/16/80)	4
9. Area west of the dam. (12/16/80)	5
10. Overview of the impoundment. (12/16/80)	5
11. 6-foot by 22-foot culvert 150 feet downstream of the dam. (12/16/80)	6
12. Potential hazard area about 500 feet downstream of the dam. (12/16/80)	6

SITE PLAN  
LAKE CAROLINE DAM

PAGE A





1. UPSTREAM FACE OF DAM FROM THE WEST ABUTMENT SHOWING BRUSH AND TREES AND LACK OF RIPRAP. (12/16/80)



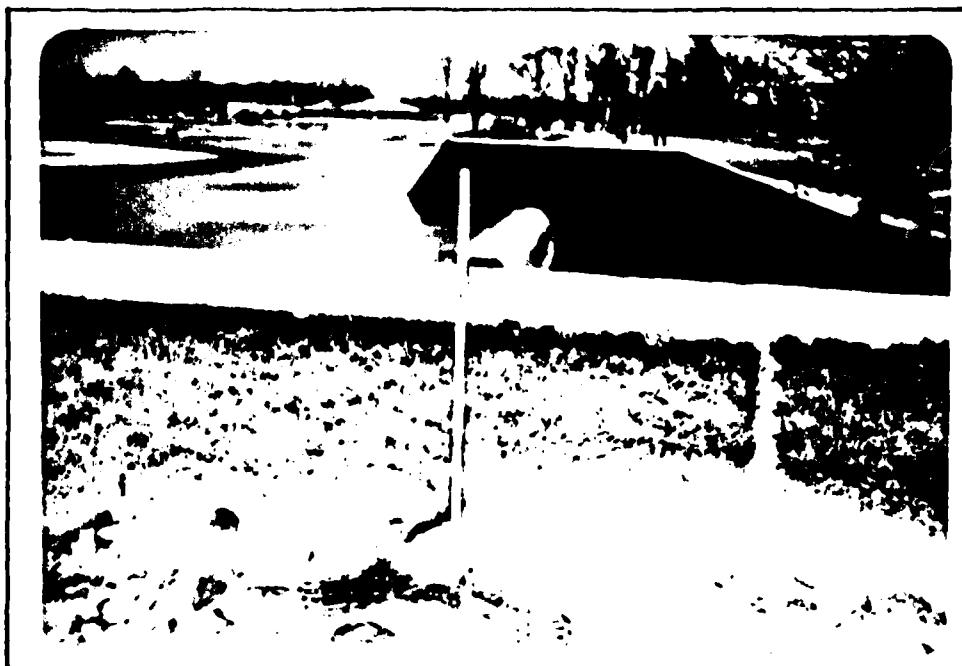
2. LOOKING UPSTREAM AT THE SPILLWAY. (12/16/80)



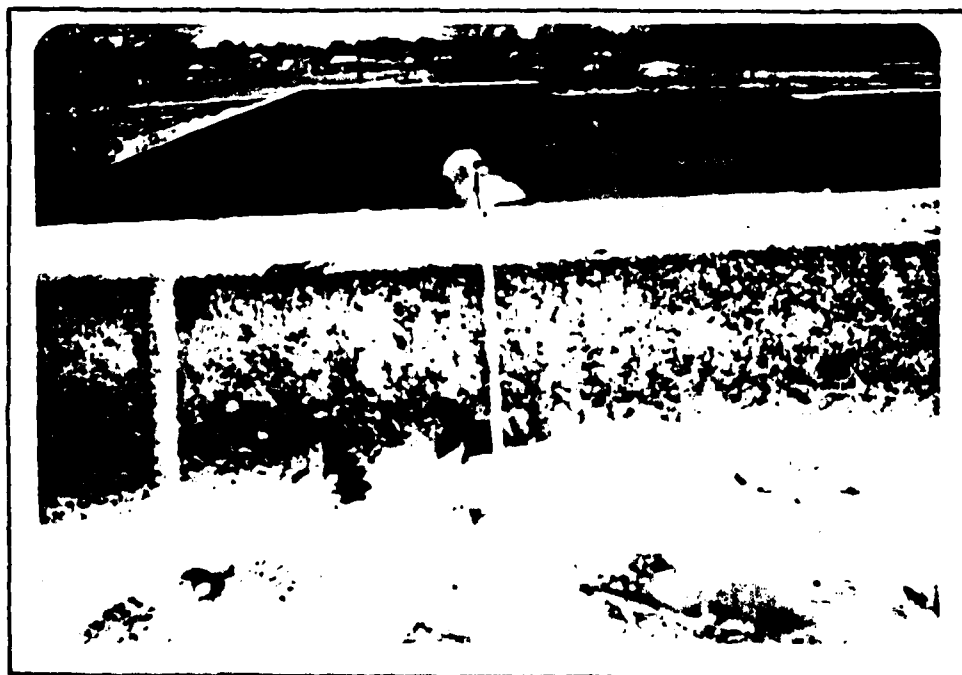
3. SPILLWAY FROM EAST SIDEWALL. (12/16/80)



4. EMBANKMENT BELOW GRADE JUST WEST OF SPILLWAY SIDEWALL. (12/16/80)



5. EMBANKMENT ABOUT ONE FOOT BELOW GRADE ALONG WEST SPILLWAY SIDEWALL. (12/16/80)



6. EMBANKMENT ABOUT ONE FOOT BELOW GRADE ALONG EAST SPILLWAY SIDEWALL. (12/16/80)





7. OVER ALL CONDITION OF UPSTREAM FACE OF DAM EMBANKMENT. (12/16/80)



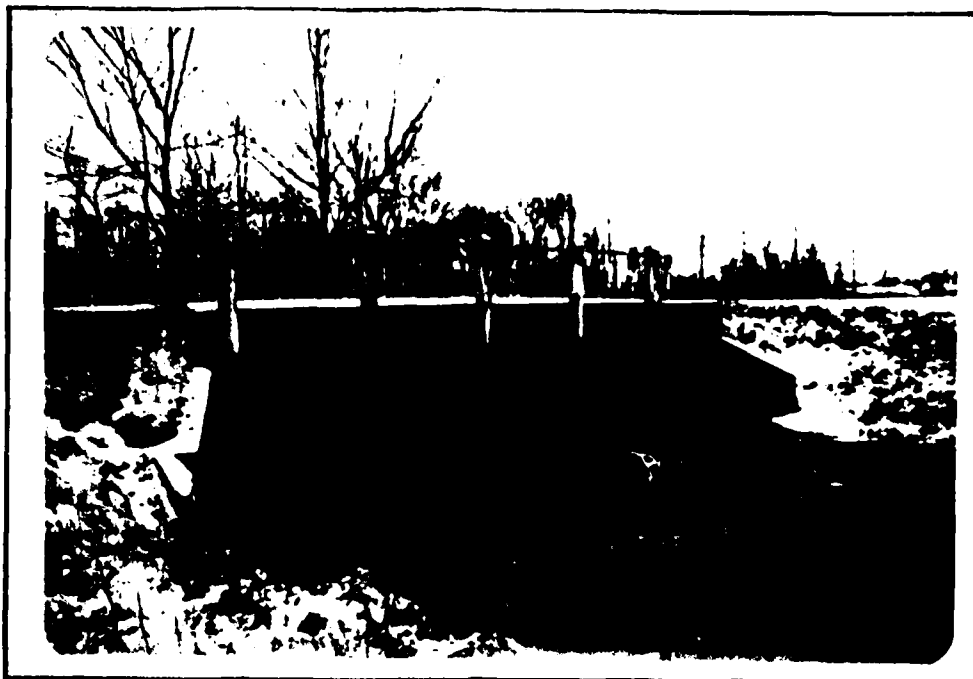
8. TYPICAL VEGETATION GROWTH ON UPSTREAM FACE OF DAM EMBANKMENT. (12/16/80)



9. AREA WEST OF THE DAM. (12/16/80)



10. OVERVIEW OF THE IMPOUNDMENT. (12/16/80)



11. 6-FOOT BY 22-FOOT CULVERT 150 FEET DOWNSTREAM OF THE DAM. (12/16/80)



12. POTENTIAL HAZARD AREA ABOUT 500 FEET DOWNSTREAM OF THE DAM. (12/16/80)

APPENDIX D  
HYDROLOGIC AND HYDRAULIC  
ENGINEERING DATA

LAKE CAROLINE DAM

APPENDIX D

HYDROLOGIC AND HYDRAULIC  
ENGINEERING DATA

TABLE OF CONTENTS

	<u>SHEET</u>
Checklist, Hydrologic and Hydraulic Engineering Data	1
HEC-1, Revised, Flood Hydrograph Package	2
Drainage Area, Surface Areas and PMP Calculations	3
Snyder coefficients & Stage - Discharge Data	4
Stage - Discharge Computations, Dam with Low Point Top of Dam El. 68.8	5
Stage - Discharge Computations, Highway Embankment & Culvert Discharge	6
Stage - Discharge Computations Assuming Crest of Dam Minimum Elev. 70.0	7
Stage - Discharge Curves	8
HEC-1 Dam Safety Version, Non-Breach Computer Output Crest of Dam Elev. 68.8	9 through 12
HEC - 1 Dam Safety Version Non-Breach Computer Output Assuming Crest of Dam Minimum Elev. 70.0	13 through 16

CHECK LIST  
HYDROLOGIC AND HYDRAULIC  
ENGINEERING DATADRAINAGE AREA CHARACTERISTICS: UrbanELEVATION TOP NORMAL POOL (STORAGE CAPACITY): Elev. 66.0 (32 Acre-Feet)ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): Elev. 68.8 (104 Acre-Feet)ELEVATION MAXIMUM DESIGN POOL: Elev. 70.0ELEVATION TOP DAM: Elev. 68.8, Low Point Top of Dam

## SPILLWAY

a. Elevation 66.0b. Type Concrete Ogeec. Width Ogee Shaped Crestd. Length 45 Feete. Location Spillover Near Center of Damf. Number and Type of Gates None

## OUTLET WORKS:

a. Type 36-inch diameter opening through base of Ogeeb. Location 3 feet from right side of spillwayc. Entrance invert Elev. 60.0d. Exit invert Elev. 59.0e. Emergency draindown facilities timber slide gate

## HYDROMETEOROLOGICAL GAGES:

a. Type None within watershedb. Location N/Ac. Records N/AMAXIMUM NON-DAMAGING DISCHARGE: Not determined

HEC-1, REVISED  
FLOOD HYDROGRAPH PACKAGE

The original "Flood Hydrograph Package" (HEC-1), developed by the Hydrologic Engineering Center, Corps of Engineers, has been modified for use under the National Dam Inspection Program. The "Flood Hydrograph Package (HEC-1), Dam Safety Version", hereinafter referred to as, HEC-1, Rev., has been modified to require less detailed input and to include a dam breach analysis. The required input is obtained from the field inspection of a dam, any available design/evaluation data, relatively simple hydraulic calculations, or information from the USGS Quadrangle maps. The input format is flexible in order to reflect any unique characteristics of an individual dam.

HEC-1, Rev. computes a reservoir inflow hydrograph based on individual watershed characteristics such as: area, percentage of impervious surface area, watershed shape, and hydrograph characteristics determined from regional correlation studies by the Corps of Engineers, Baltimore District. The inflow is routed through the reservoir using spillway discharge data obtained from the field inspection or design data. Flood storage capacity is determined from USGS maps or design information and verified by the field inspection. In the event a spillway cannot discharge 0.5 PMF without overtopping and failure of the dam, downstream channel characteristics obtained from the field inspection and USGS maps are input and flows are routed downstream to the damage center and a dam breach analysis is performed.

Included in this Appendix are the HEC-1, Rev. pertinent input values and a summary print-out.

*1" High "hazard structures only*



O'BRIEN & GERE

SUBJECT LAKE CAROLINE DAM	SHEET 3	BY R.E.P. ✓ #	DATE 12/19/80 1/9/81	JOB NO. 1841-014
------------------------------	------------	---------------------	----------------------------	---------------------

HYDROLOGY CALCULATIONS

DRAINAGE AREA (PLANIMETERED FROM USGS QUAD SHEET): 2.2 SQ. MI.

SURFACE AREAS OF LAKE CAROLINE

ELEVATION

AREA (A KF)

59

0

66 (NORMAL POOL)

13.5

80

294

PMP CALCULATIONS (HMR 33)

AREA IS IN ZONE 6

24-HOUR, 200 SQ. MI. RAINFALL = 23.5 INCHES

<u>HR.</u>	<u>%</u>	<u>RAINFALL</u>	<u>ΔKF</u>
6	113	26.6"	26.6"
12	123	28.9"	2.3"
24	132	31.0"	2.1"
48	142	33.4"	2.4"



PROJECT	SHEET	BY	DATE	JOB NO.
LAKE CAROLINE DAM	4	KLB VJB	12/22/80 1/12/81	1841-014

SNYDER COEFFICIENTS (INFORMATION PROVIDED BY BALD. COE)

AREA IS IN ZONE 4B

$$C_p = 0.43$$

$$C_t = 0.60$$

$$T_p = C_t (L \cdot L_{ca})^{0.3}$$

$$L \approx 1.7 \text{ MILES}, \quad L_{ca} \approx 0.5 \text{ MILES}$$

$$T_p = 0.6 (1.7 \cdot 0.5)^{0.3} = 0.57 \text{ HOURS}$$

### STAGE-DISCHARGE

$$\text{SPILLWAY} \rightarrow Q_s = C L_s H_s^{3/2}, \quad C \approx 3.5 \text{ (OGEE SPILLWAY)}$$

DISCHARGE NOTCH  $\sim 6''$  BELOW SPWY. CREST, 5' WIDE

$$\text{SPILLWAY } L_s = 45 \text{ FT.}$$

$$\text{TOP OF DAM} \rightarrow Q_d = C L_d H_d^{3/2}, \quad C \approx 3.0 \text{ (SHORT BROAD-CRESTED WEIR)}$$

$$L_d = 1180 \text{ FT. (VARIABLE TOP ELEVATION)}$$

$$\text{ABUTMENTS} \rightarrow Q_a = C L_a H_a^{3/2}, \quad C \approx 2.8 \text{ (LONG BROAD-CRESTED WEIR)}$$

$$\text{AVG. ABUTMENT SLOPE} \approx 65H:1V$$



OBRIEN &amp; GERE

SHEET

BY

DATE

JOB NO

LAKE CAROLINE DAM

5

KLB

12/23/80

1841-014

Spill - Discharge Computations, Dam with Low Pt. Top of Dam El. 68.8

ELEV.	H <sub>1</sub> (FT.)	Q <sub>1</sub> (CFS)	H <sub>2</sub> (FT.)*	L <sub>1</sub> (FT)	Q <sub>2</sub> (CFS)	H <sub>3</sub> (FT.)*	L <sub>2</sub> (FT)	Q <sub>3</sub> (CFS)	Q <sub>TOTAL</sub> (CFS)
-------	----------------------	----------------------	-----------------------	---------------------	----------------------	-----------------------	---------------------	----------------------	--------------------------

65.5	—	0							0
66	0	6**							6
67	1	172							172
68	2	465							465
68.8	2.8	761	0	—	0				761
69	3	842	0.1	180	17				859
70	4	1,287	0.6	850	1,185	0	—	0	2,472
71	5	1,791	1.4	1050	5,218	0.5	130	129	7,138
72	6	2,348	2.1	1135	10,362	1	260	728	13,438
75	9	4,292	5.0	1135	38,069	2.5	650	7,194	49,555
80	14	8,300	10.0	1135	107,676	5	1300	40,696	156,672

\* - ABUTMENT HEAD AND TOP OF DAM HEAD ARE AVERAGE FIGURES SINCE ELEVATIONS ARE VARIABLE.

\*\* - DISCHARGE THROUGH NOTCH IN SPILLWAY.

A HIGHWAY EMPANKMENT LOCATED 100 FT DOWNSTREAM OF THE DAM WOULD CONTROL DISCHARGE BEYOND EL. 69.7 (REFER TO SH 8) HIGHWAY CULVERT IS 6 FT. HIGH BY 22 FT. WIDE. THE TOP OF THE HIGHWAY IS APPROXIMATELY ELEVATION 69.5 ABOVE THE CULVERT AND GRADES GENTLY UPWARD IN EITHER DIRECTION.

SUBJECT	SHEET	BY	DATE	JOB NO.
LAKE CAROLINE DAM	6	RRC	12/24/80	1841-014

1/13/81

### HIGHWAY EMBANKMENT & CULVERT DISCHARGE

Road Culvert  $Q = \frac{K'}{n} b^{8/3} S^{1/2}$  } Elev 59 to 65 }  $b = 22'$ ,  $S = 0.001'$ ,  $n = 0.016$  (Pg 7-22 34K)

ABOVE ELEV. 65,  $Q_c = CA \sqrt{2gH_c}$  ( $C \approx 0.5$ , 132 FT.)

HIGHWAY OVERTOPPING  $\rightarrow Q_o = CLH_o^{3/2}$ ;  $C \approx 3.0$ ,  $L \approx 30$  FT.

ABUTMENT OVERTOPPING  $\rightarrow Q_a = CLH_a^{3/2}$ ;  $C \approx 3.0$ , SLOPES  $\approx 10:11:14$

Elev.  $H_o$ (FT)  $Q_c$ (CFS)  $H_H$ (FT)  $Q_H$ (CFS)  $H_a$ (FT)\*  $L_a$ (FT)  $Q_a$ (CFS)  $Q_{TOTAL}$ (CFS)

59	0	Open Channel Flow	0					0
60	1		61					61
61	2		184					184
63	4		529					529
65	6		958					958
66	7		1192					1192
66	4		1059					1059
67	5		1184					1184
69.5	7.5		1450	0	0	0	0	1450
70	8	Orifice Flow	1498	0.5	32	0.25	100	1568
71	9		1589	1.5	165	0.75	300	2339
72	10		1675	2.5	356	1.25	500	4127
73	11		1757	3.5	589	1.75	700	7208
75	13		1910	5.5	1161	2.75	1100	18,120
80	18		2247	10.5	3062	5.25	2100	81,094

\* - AVERAGE HEAD DUE TO VARIABLE ELEVATION

SUBJECT	SHEET	BY	DATE	JOB NO.
Lake Cardine Dam	7	JD	2/11/81	1841-014

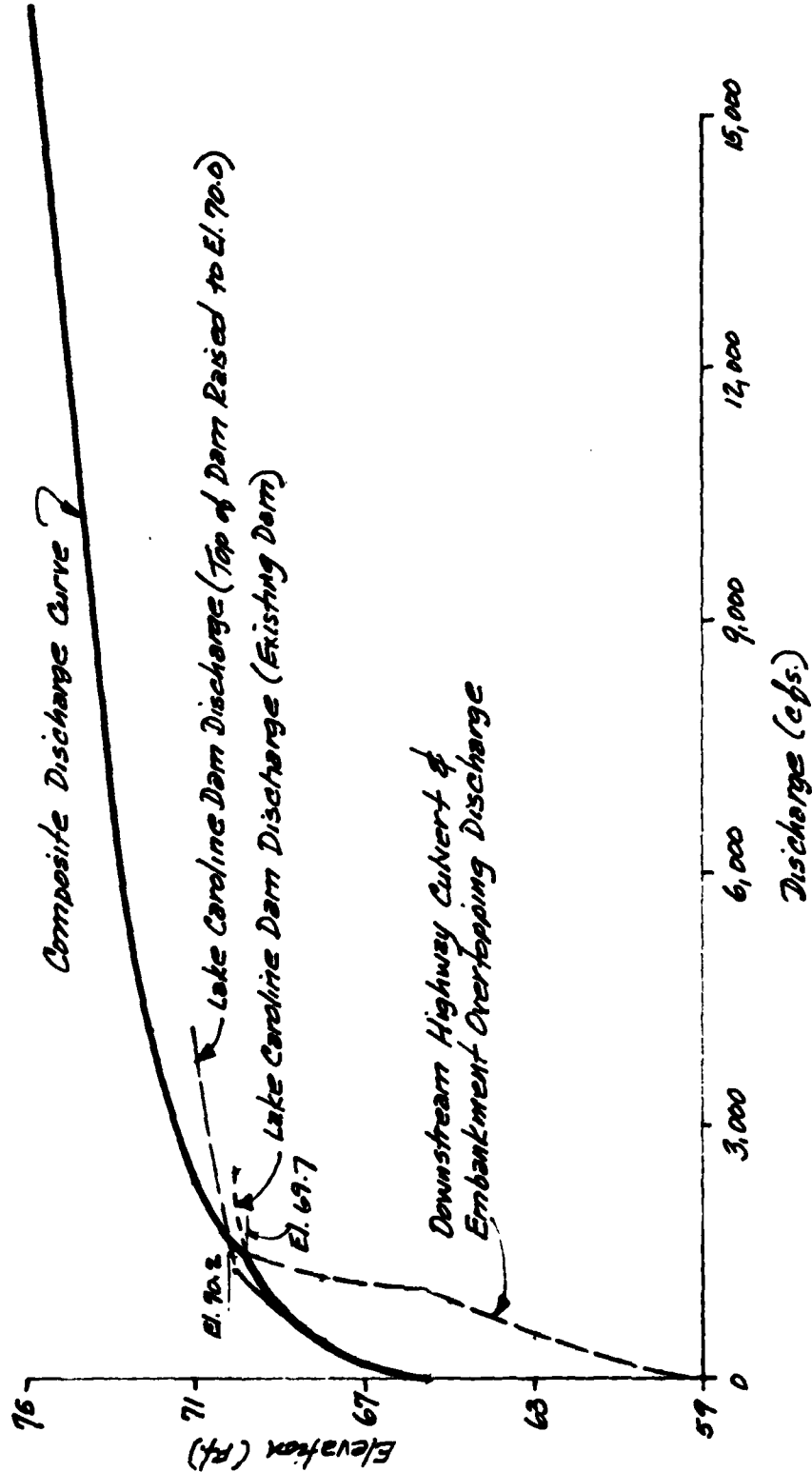
### Stage-Discharge Computations Assuming Crest of Dam Minimum

Elev. 70.0	SPILLWAY		DAM			ABUTMENTS			
Elev.	$H_d(PH)$	$Q_d(Cfs)$	$H_d^*(PH)$	$L_d(PD)$	$Q_d(Cfs)$	$H_d^*(PH)$	$L_d(PD)$	$Q_d(Cfs)$	$Q_{TOT}(Cfs)$
65.5	—	0							0
66	0	6**							6
67	1	172							172
68	2	465							465
69	3	842							842
70	4	1287	0	—	0	0	—	0	1287
71	5	1,791	0.8	1050	2,254	0.5	130	129	4,174
72	6	2,348	1.6	1135	6,891	1.0	260	728	9,967
75	9	4,292	4.0	1135	27,240	2.5	650	2,194	38,726

- \* Abutment head & top of dam head are average values  
 \*\* Discharges through notch in spillway.

A highway embankment located  $\approx 100'$  downstream of the dam would control discharge beyond El. 70.2 (Refer to SH B). Highway culvert is 6' high by 22' wide. Highway surface is approximately El. 69.5 at the culvert and grades gently upward in either direction.

SUBJECT	Sheets	By	DATE	JOB NO.
Lake Caroline Dam	8	RRB	12/24/61	1841-014



FLOOD HYDROGRAPH PACKAGE (HEC-1)  
 DAM SAFETY VERSION JULY 1978  
 LAST MODIFICATION 01 APR 80  
 \*\*\*\*\*

1	A1	300	0	10	0	0	0	0	-4	0
2	A2	5	9	1	0	0	0	0	0	0
3	A3	1	2	.3	.4	.5	.6	.7	.8	1.0
4	B1	0	INFLOW							
5	J1	0								
6	K1	1	1	2.2	123	132	142	1	1	1
7	M	0	23.5	113						
8	P	0								
9	T	0								
10	W	.57	.60							
11	X	-1.5	-0.05	2						
12	K	1	OUTFLOW							
13	K1									
14	Y									
15	Y1	1								
16	Y4	65.5	66	67	68	68.8	69	-65.5	-1	72
17	Y4	73	75	80				69.7	70	71
18	Y5	0	6	172	465	761	859	1500	1568	2339
19	Y5	7208	18120	81094						4127
20	Y5	0	13.5	294						
21	Y5	0	66	80						
22	Y5	59								
23	Y5	65.5								
24	Y5	68.8								
25	Y5	99								
26	Y5									
27	Y5									

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

RUNOFF HYDROGRAPH AT  
 ROUTE HYDROGRAPH TO  
 END OF NETWORK

\*\*\*\*\*  
 FLOOD HYDROGRAPH PACKAGE (HEC-1)  
 DAM SAFETY VERSION JULY 1978  
 LAST MODIFICATION 01 APR 80  
 \*\*\*\*\*

JOB SPECIFICATION									
NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
300	0	10	0	0	0	0	0	-4	0
			JOPER	NWT	LROPT	TRACE			
			5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED

RTIOS= .10 .20 .30 .40 .50 .60 .70 .80 1.00  
 NPLAN= 1 NRTIO= 9 LRTIO= 1

NOTE:  
 Material on Sheets  
 9 thru 12 Crest  
 of Dam Min Elev.  
 68.8

# SUB-AREA RUNOFF COMPUTATION

## RUNOFF TO LAKE CAROLINE

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JFRT	INAME	ISTAGE	IAUTO
INFLOW	0	0	0	0	0	1	0	0

## HYDROGRAPH DATA

IHYDG	IUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	2.20	0.00	2.20	0.00	0.000	0	1	0

## PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	23.50	113.00	123.00	132.00	142.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .800

## LOSS DATA

LROFT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.05	0.00	0.00

## UNIT HYDROGRAPH DATA

TP= .57 CP= .60 NTA= 0

## RECESSION DATA

STRTO= -1.50 GRCSN= -.05 RTIOR= 2.00

UNIT HYDROGRAPH 21 END-OF-PERIOD ORDINATES, LAG= .57 HOURS, CP= .60 VOL= 1.00

199.	712.	1246.	1452.	1253.	933.	695.	517.	385.	287.
213.	159.	118.	88.	66.	49.	36.	27.	20.	15.
11.									

## END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	NO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
SUM	26.70	24.29	2.40	208419.									
	( 678.)	( 617.)	( 61.)	( 5901.77)									

# HYDROGRAPH ROUTING

## OUTFLOW FROM LAKE CAROLINE

ISTAG	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
OUTFLOW	1	0	0	0	0	1	0	0
QLOSS	AVG	IRIS	ISAME	IOPT	IPMP		LSTR	
0.0	0.000	1	1	0	0		0	
NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT	
1	0	0	0.000	0.000	0.000	-66.	-1	
STAGE	65.50	66.00	68.00	68.80	69.00	69.70	70.00	72.00
	73.00	75.00						
FLOW	0.00	6.00	172.00					
	7208.00	18120.00	81094.00					

SURFACE AREA= 0. 14. 294.

CAPACITY= 0. 32. 1761.

ELEVATION= 59. 66. 80.

CREL	SPWID	COBW	EXPW	ELEV	COOL	CAREA	EXPL
65.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TOPEL	COOD	EXPD	DAMWID
68.8	0.0	0.0	0.

PEAK OUTFLOW IS 696. AT TIME 40.83 HOURS

PEAK OUTFLOW IS 1528. AT TIME 40.67 HOURS

PEAK OUTFLOW IS 2190. AT TIME 40.67 HOURS

PEAK OUTFLOW IS 3175. AT TIME 40.67 HOURS

PEAK OUTFLOW IS 4100. AT TIME 40.67 HOURS

PEAK OUTFLOW IS 5299. AT TIME 40.50 HOURS

PEAK OUTFLOW IS 6311. AT TIME 40.50 HOURS

PEAK OUTFLOW IS 7258. AT TIME 40.50 HOURS

PEAK OUTFLOW IS 9499. AT TIME 40.50 HOURS



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PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS  
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)  
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7	RATIO 8	RATIO 9
				.10	.20	.30	.40	.50	.60	.70	.80	1.00
RATIOS APPLIED TO FLOWS												
HYDROGRAPH AT INFLOW	(	2.20	1	1100.	2201.	3301.	4402.	5502.	6602.	7703.	8803.	11004.
	(	5.70)	(	31.16)	( 62.32)	( 93.48)	( 124.64)	( 155.80)	( 186.96)	( 218.12)	( 249.28)	( 311.60)
ROUTED TO	(	2.20	1	696.	1528.	2190.	3175.	4100.	5299.	6311.	7258.	9499.
	(	5.70)	(	19.70)	( 43.26)	( 62.00)	( 89.90)	( 116.09)	( 150.06)	( 178.72)	( 205.53)	( 268.99)

SUMMARY OF DAM SAFETY ANALYSIS

TOP OF DAM  
68.80  
104.  
761.

INITIAL VALUE  
65.50  
25.  
0.

ELEVATION  
STORAGE  
OUTFLOW

PLAN 1 .....

RATIO OF PMF	MAXIMUM RESERVOIR W.S. ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	68.62	0.00	97.	696.	0.00	40.83	0.00
.20	69.82	1.02	152.	1528.	3.00	40.67	0.00
.30	70.81	2.01	212.	2190.	4.67	40.67	0.00
.40	71.47	2.67	261.	3175.	5.67	40.67	0.00
.50	71.98	3.18	305.	4100.	6.33	40.67	0.00
.60	72.38	3.58	342.	5299.	6.67	40.50	0.00
.70	72.71	3.91	374.	6311.	7.00	40.50	0.00
.80	73.01	4.21	406.	7258.	7.33	40.50	0.00
1.00	73.42	4.62	452.	9499.	7.83	40.50	0.00

NO. 12  
Q Top of  
Dam  
El. 68.8



\*\*\*\*\*

SUB-AREA RUNOFF COMPUTATION

RUNOFF TO LAKE CAROLINE

ISTAG ICOMP IECON ITAPE JPLT JPRT INAME ISTAGE IAUTO  
INFLOW 0 0 0 0 0 0 0 0 0

HYDROGRAPH DATA  
INHYDG IUHG TAREA SNAP TRSDA TRSPC RATIO ISNOW ISAME LOCAL  
1 1 2.20 0.00 2.20 0.00 0.000 0 1 0

PRECIP DATA  
SPFE PMS R6 R12 R24 R48 R72 R96  
0.00 23.50 113.00 123.00 132.00 142.00 0.00 0.00

TRSPC COMPUTED BY THE PROGRAM IS .800

LOSS DATA  
LROPT STRKR DLTKR RTIOL ERAIN STRKS RTIOK STRTL CNSTL ALSHX RTIMP  
0 0.00 0.00 1.00 1.00 0.00 0.00 1.00 1.00 .05 0.00 0.00

UNIT HYDROGRAPH DATA  
TP= .57 CP= .60 NTA= 0

RECESSION DATA  
STRTO= -1.50 QRCN= -.05 RTIOR= 2.00

UNIT HYDROGRAPH 21 END-OF-PERIOD ORDINATES, LAG= .57 HOURS, CP= .60 VOL= 1.00  
199. 712. 1246. 1452. 1253. 933. 695. 517. 385. 287.  
213. 159. 118. 88. 66. 49. 36. 27. 20. 15.

END-OF-PERIOD FLOW  
MO.DA HR.MN PERIOD RAIN EXCS LOSS COMP Q MO.DA HR.MN PERIOD RAIN EXCS LOSS COMP Q  
0 26.70 24.29 2.40 208419. 26.70 24.29 2.40 208419.  
SUM ( 617. ) ( 61. ) ( 5901.77 )

# HYDROGRAPH ROUTING

## OUTFLOW FROM LAKE CAROLINE

ISTAQ	ICOMP	TECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
OUTFLOW	1	0	0	0	0	1	0	0
QLOSS	CLOSS	AVG	ROUTING DATA		IPNP	LSTR		
0.0	0.000	0.00	1	1	0	0		
NSTPS	NSTRL	LAG	AMSKK	X	TSK	STORA	ISPRAI	
1	0	0	0.000	0.000	0.000	-66.	-1	

STAGE	65.50	67.00	68.00	69.00	70.00	70.20	71.00	72.00	73.00
75.00									
FLOW	0.00	172.00	465.00	842.00	1287.00	1650.00	2339.00	4127.00	7208.00
18120.00									

SURFACE AREA= 0. 14. 294.

CAPACITY= 0. 32. 1761.

ELEVATION= 59. 66. 80.

CREL	SPWID	COQM	EXPW	ELEV	COOL	CAREA	EXPL
65.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TOPEL	COOD	EXPD	DAMWID
70.0	0.0	0.0	0.

PEAK OUTFLOW IS 698. AT TIME 40.83 HOURS

PEAK OUTFLOW IS 1403. AT TIME 40.83 HOURS

PEAK OUTFLOW IS 2258. AT TIME 40.67 HOURS

PEAK OUTFLOW IS 3267. AT TIME 40.67 HOURS

PEAK OUTFLOW IS 4163. AT TIME 40.50 HOURS

PEAK OUTFLOW IS 5327. AT TIME 40.50 HOURS

PEAK OUTFLOW IS 6320. AT TIME 40.50 HOURS

PEAK OUTFLOW IS 7265. AT TIME 40.50 HOURS

PEAK OUTFLOW IS 9500. AT TIME 40.50 HOURS

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS  
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)  
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7	RATIO 8	RATIO 9
				.10	.20	.30	.40	.50	.60	.70	.80	1.00
HYDROGRAPH AT INFLOW	(	2.20	1	1100.	2201.	3301.	4402.	5502.	6602.	7703.	8803.	11004.
	(	5.70)	(	31.16)	62.32)	93.48)	124.64)	155.80)	186.96)	218.12)	249.28)	311.50)
ROUTED TO OUTFLO	(	2.20	1	698.	1403.	2258.	3267.	4163.	5327.	6320.	7265.	9500.
	(	5.70)	(	19.78)	39.72)	63.95)	92.50)	117.87)	150.84)	178.96)	205.71)	269.02)

RATIOS APPLIED TO FLOWS

SUMMARY OF DAM SAFETY ANALYSIS

TOP OF DAM
70.00
162.
1287.

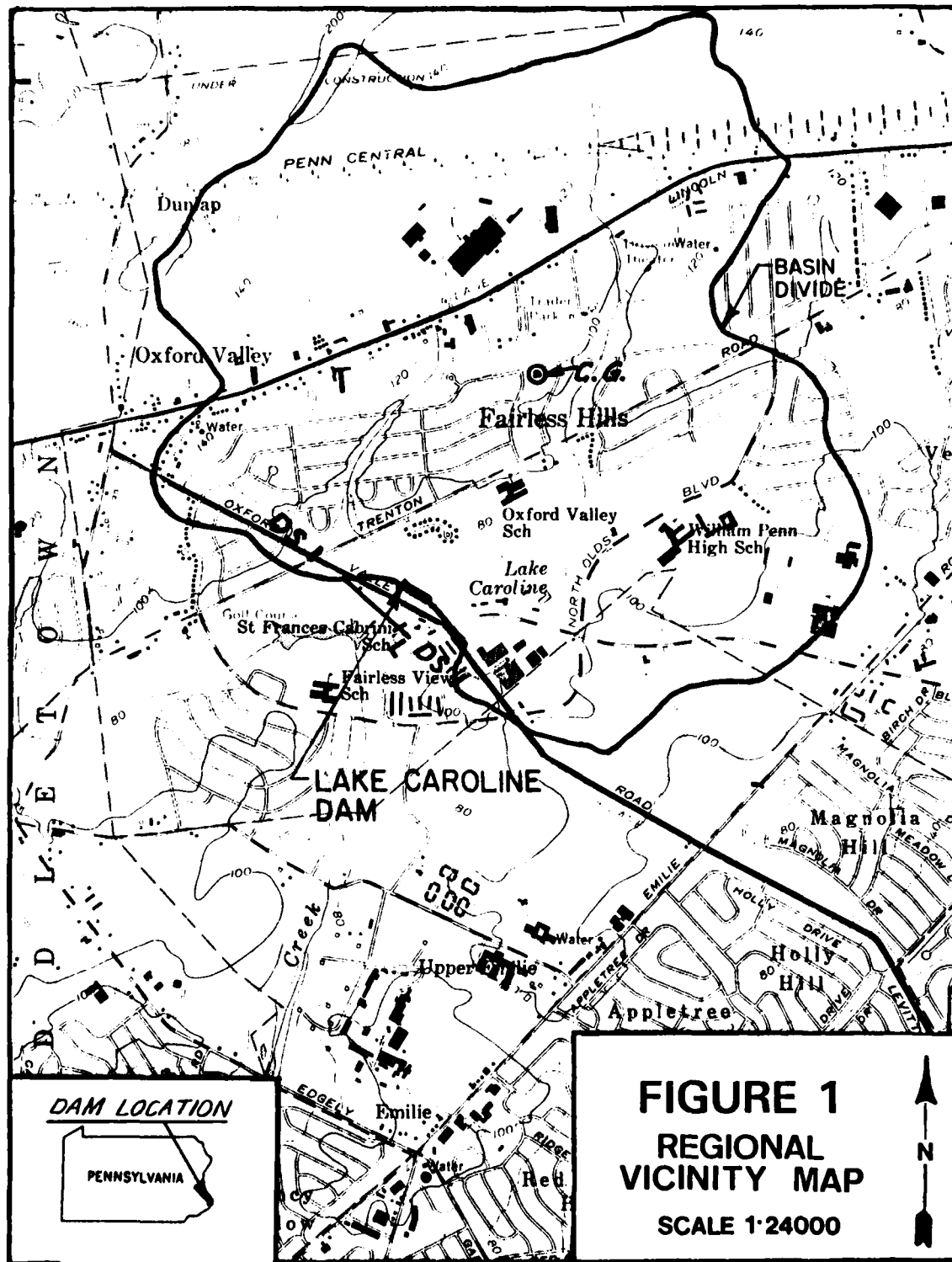
INITIAL VALUE	SPILLWAY CREST
65.50	65.50
25.	25.
0.	0.

ELEVATION	STORAGE
68.62	70.06
70.91	71.52
72.01	72.39
72.71	73.01
73.42	

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	68.62	0.00	97.	698.	0.00	40.83	0.00
.20	70.06	.06	165.	1403.	.67	40.83	0.00
.30	70.91	.91	219.	2258.	2.50	40.67	0.00
.40	71.52	1.52	266.	3267.	3.50	40.67	0.00
.50	72.01	2.01	307.	4163.	4.33	40.50	0.00
.60	72.39	2.39	343.	5327.	5.00	40.50	0.00
.70	72.71	2.71	375.	6320.	5.50	40.50	0.00
.80	73.01	3.01	406.	7265.	5.83	40.50	0.00
1.00	73.42	3.42	452.	9500.	6.33	40.50	0.00

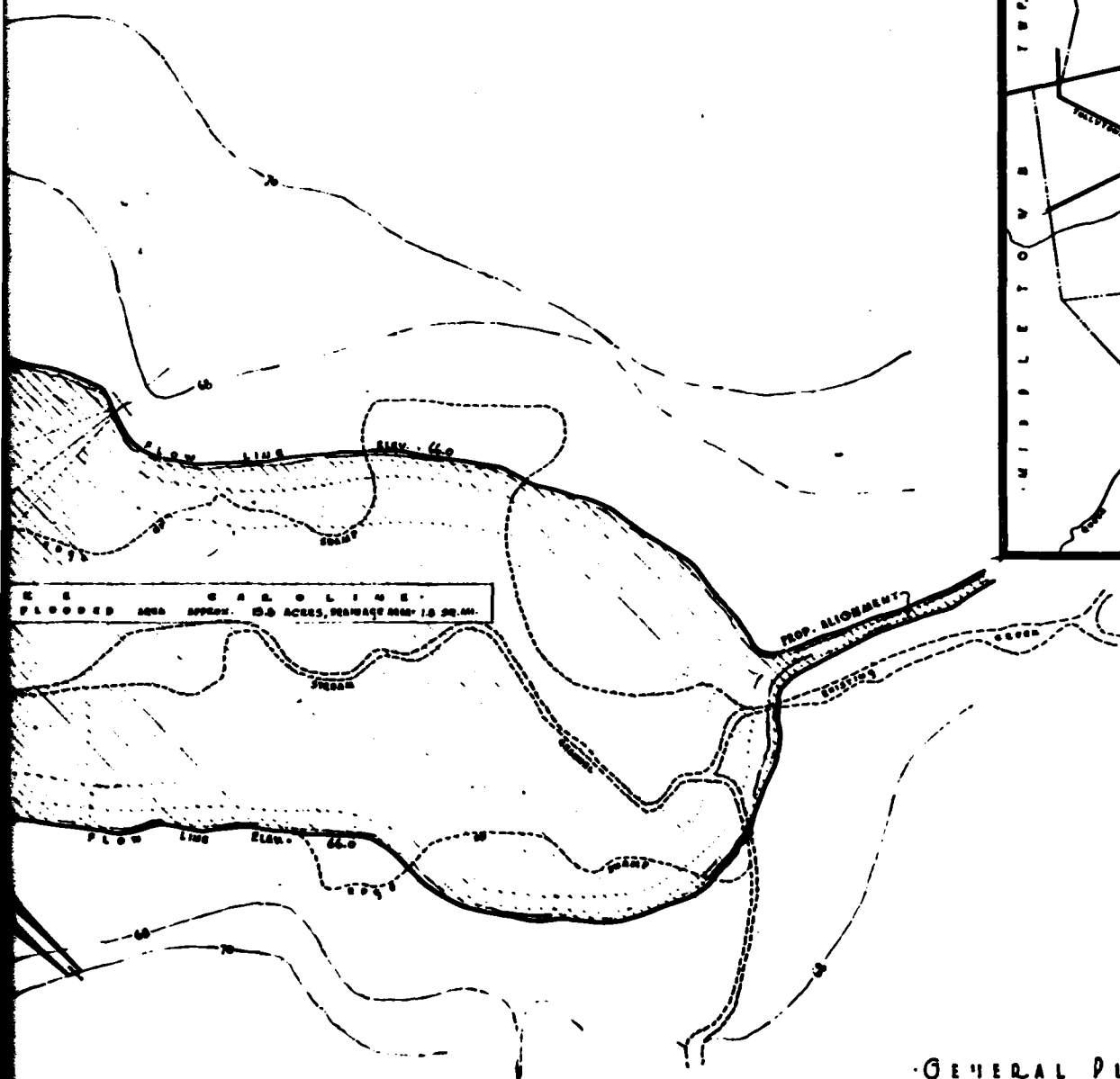
APPENDIX E  
REGIONAL VICINITY MAP  
&  
DRAWINGS

O'BRIEN & GERE

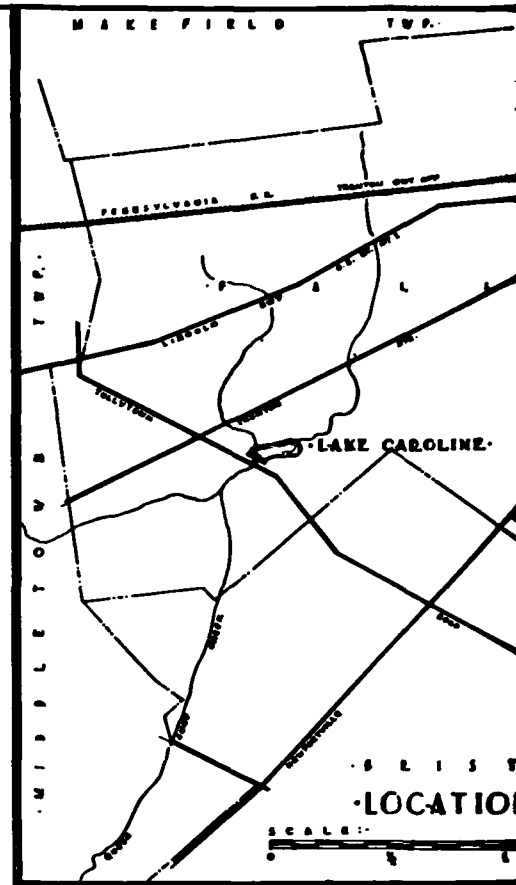




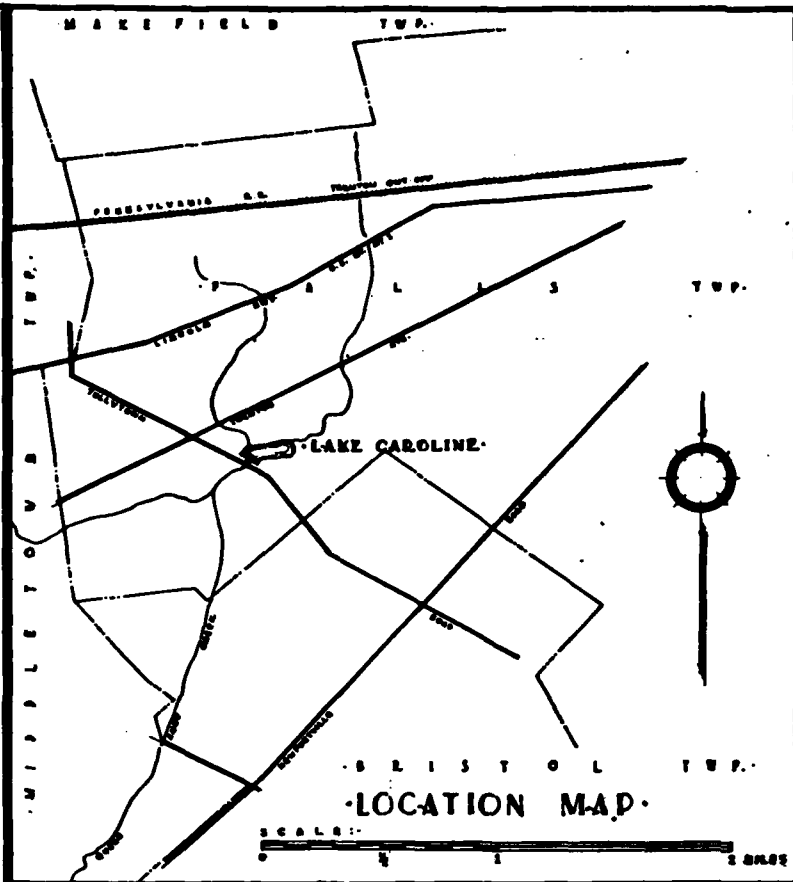




·PLOT PLAN.  
·SCALE: 1"=100'



·GENERAL PLAN OF  
·**LAKE CAROLINE**  
·FOR THE DANNERST CORPORATION.  
·FALLS TOWNSHIP - BUCKS CO. PENNSYLV.  
·SCALE: AS SHOWN.  
·JOHN W. CALDERBATH AND COMPANY. ·DEVELOPERS.  
·HOWARD H. MOY ASSOCIATES - LAND PLANNING CONSULTANTS  
·CHARLES HAYDOCK - CONSULTING ENGINEER, PHILADELPHIA  
·HOWARD E. LEVIN, JR. - REGISTERED PROFESSIONAL ENGINEER



# GENERAL PLAN OF LAKE CAROLINE.

OF THE DANHERST CORPORATION.  
ALLS TOWNSHIP - BUCKS CO. PENNSYLVANIA.  
SCALE: AS SHOWN.

AUGUST 27 1951

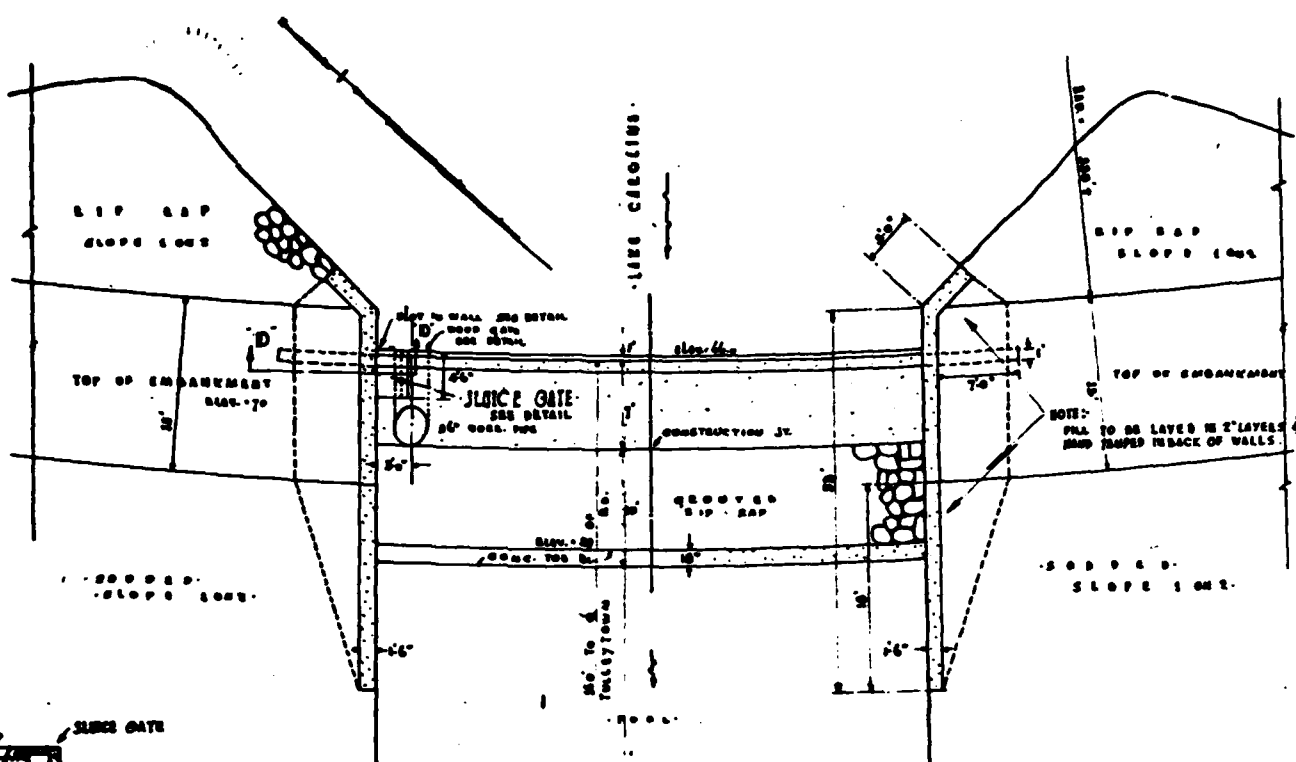
DR. W. GALBRAITH AND COMPANY. DEVELOPERS.

EDWARD S. MOTT ASSOCIATES - LAND PLANNING CONSULTANTS.

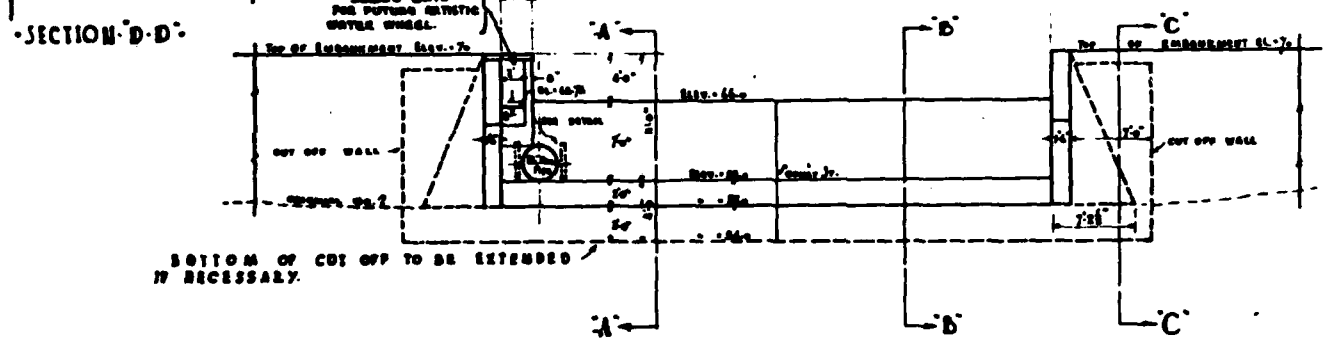
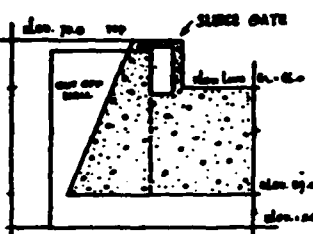
CHARLES SAYDOCK - CONSULTING ENGINEER, PHILADELPHIA PA.

EDWARD S. LAFAN, JR. - REGISTERED PROFESSIONAL ENGINEER, HARRISBURG, PA.

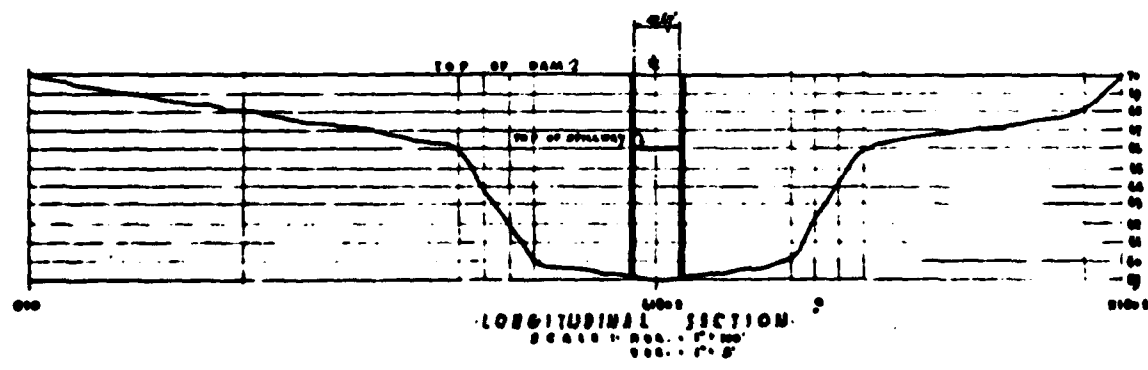
**SHEET 2**



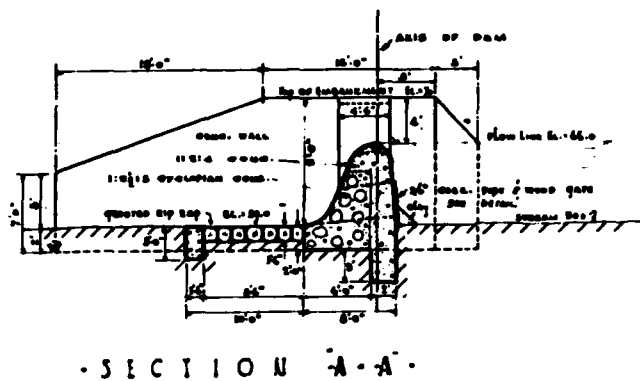
PLAN  
SCALE: 1" = 10'



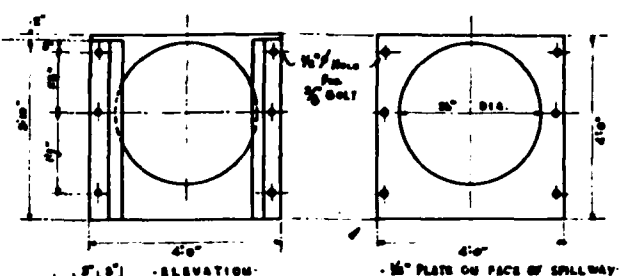
ELEVATION



LONGITUDINAL SECTION  
SCALE: 1" = 10'

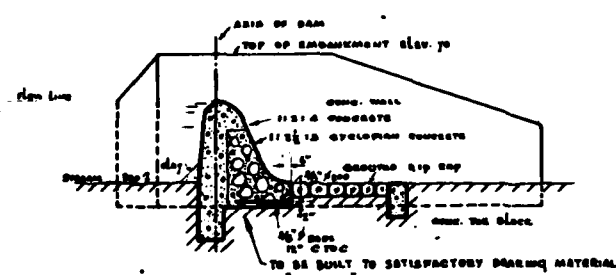


SECTION A-A

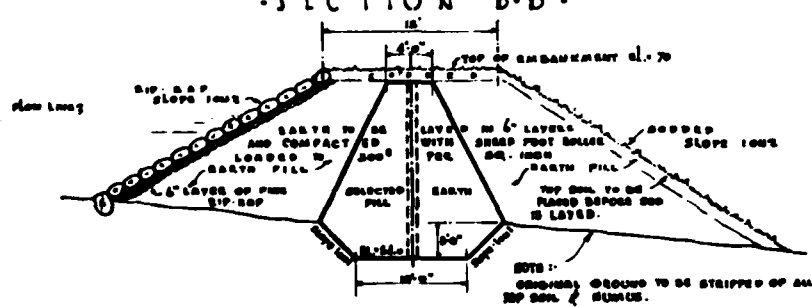


BRACKET DETAIL

DETAIL OF BRACKET & WOOD GATE FOR END



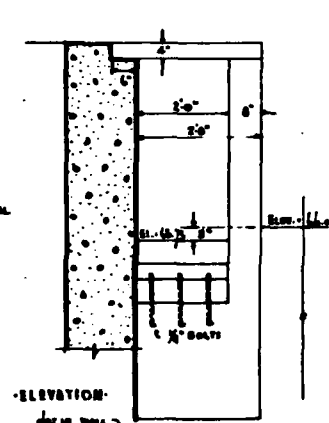
SECTION B-B



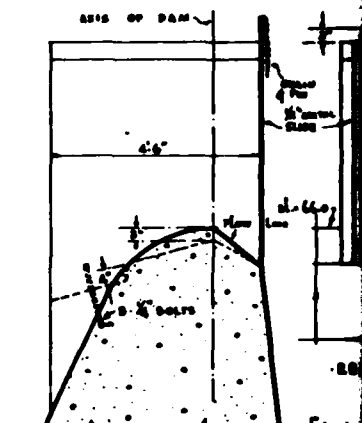
SECTION THROUGH EMBANKMENT

SECTION D-D

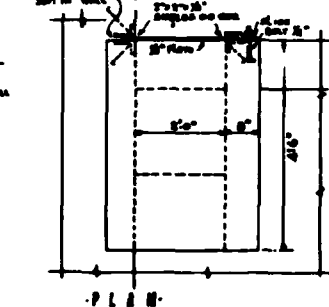
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ELEVATION

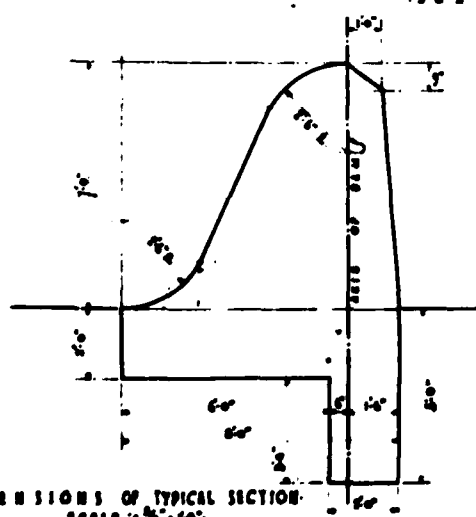


SECTION & SIDE VIEW



PLAN

DETAIL OF SLUICE GATE FOR WATER



DIMENSIONS OF TYPICAL SECTION

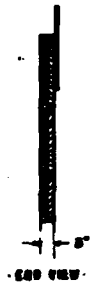
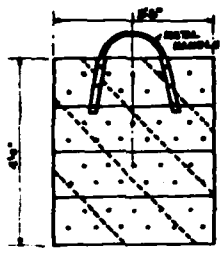
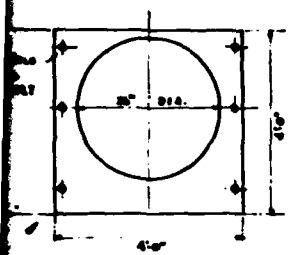
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PLAN & DETAILS OF EMBANKMENT & SPILLWAY FOR DAM AT

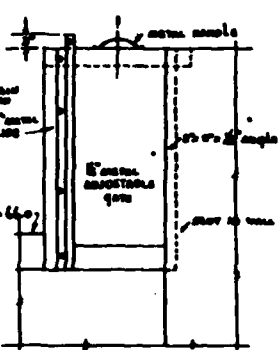
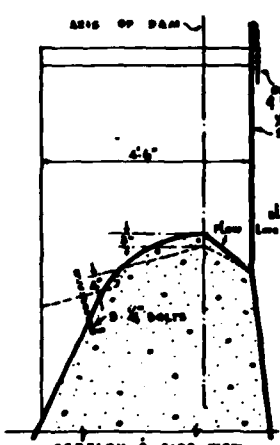
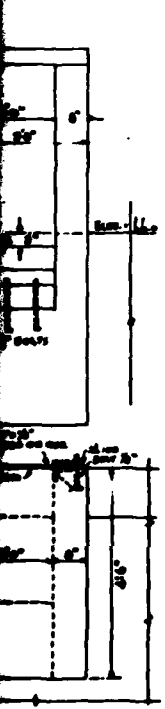
# LAKE CAROLIN

FOR THE DANNERST CORPORATION  
FALLS TOWNSHIP - BUCKS CO. PENNSYLVANIA  
SCALE: AS SHOWN

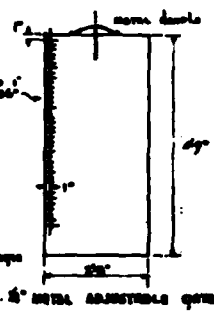
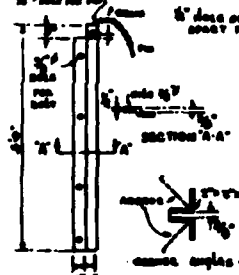
DESIGNED BY: DANNERST CORPORATION, FALLS TOWNSHIP, PA.  
DRAWN BY: J. A. DANNERST, FALLS TOWNSHIP, PA.



DETAIL OF BRACKET & WOOD GATE FOR END OF 3/4" PIPE.  
SCALE: 1/4" = 1'-0"



SECTION & SIDE VIEW



DETAIL OF SLUICE GATE FOR WATER WHEEL.  
SCALE: 1/4" = 1'-0"

DETAILS OF EMBANKMENT & SPILLWAY  
DAM AT

# LAKE CAROLINE

THE JANNERST CORPORATION  
TOWNSHIP - DUCKS CO. PENNSYLVANIA

AUGUST 27 1904

SHEET 3

NO. 1000000, CONSTRUCTION EQUIPMENT, PHILADELPHIA, PA.

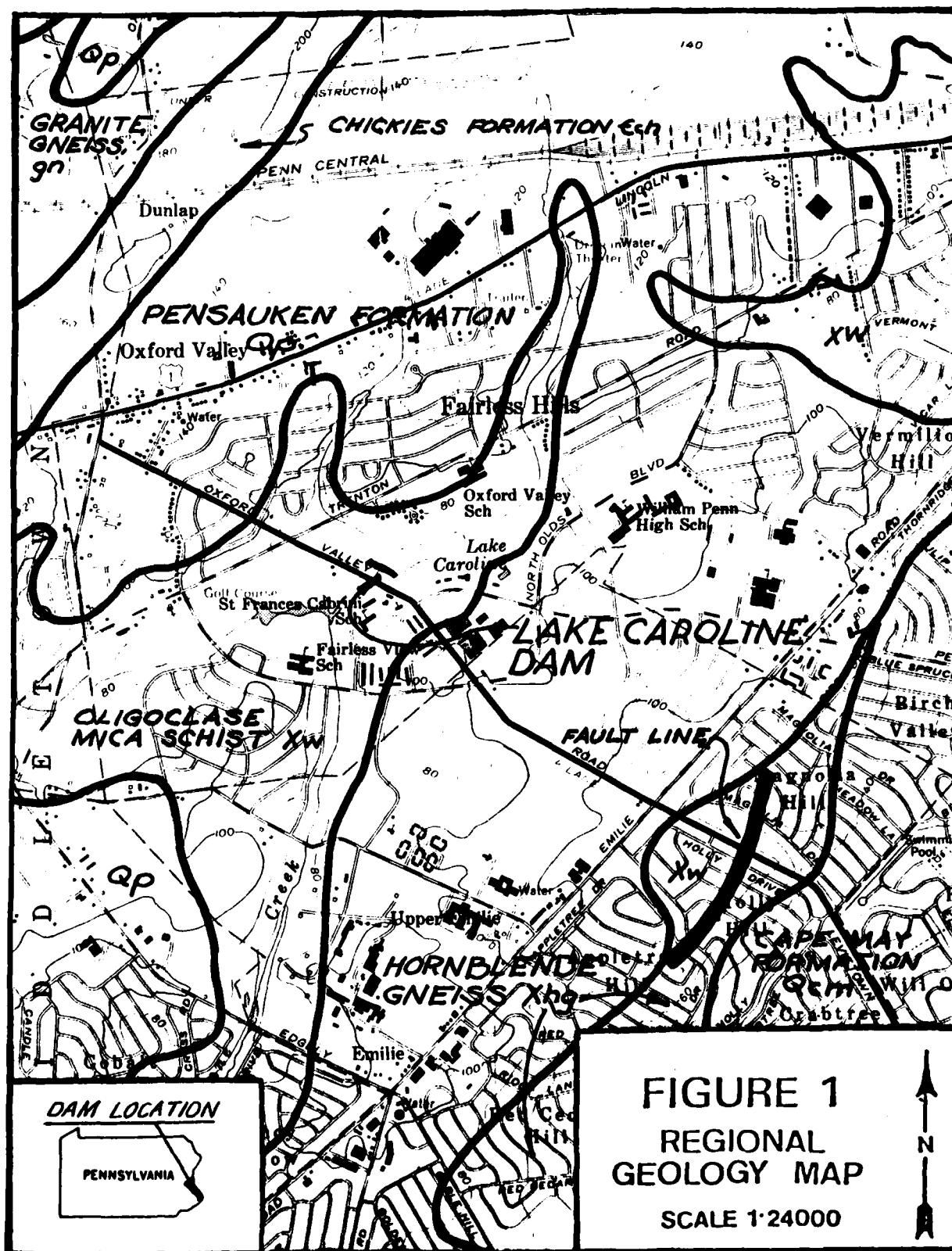
NO. 1000000, CONSTRUCTION EQUIPMENT, PHILADELPHIA, PA.

APPENDIX F  
GEOLOGY

## SITE GEOLOGY

### LAKE CAROLINE DAM

Lake Caroline Dam is located in the Lowland section of the Piedmont Physiographic Province. As shown in Figure 1, the damsite and surrounding region is underlain by Oligoclase Mica Schist (a Wissahickon Schist) of the late Pre-Cambrian or early Paleozoic age. The Oligoclase Mica Schist is exposed in the area where Queen Anne Creek has cut through the overlying Quaternary unconsolidated sediments. The Quaternary sediments are Pre-Wisconsin Pleistocene unconsolidated sand and gravel deposits in river terraces.





DATE  
FILMED  
- 8